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21.

The Histological Structure of the Normal and the Hyperplastic Thyroid in *Rasbora lateristriata* (Bleeker).

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(Plates I-III).

In an earlier publication (Smith, Coates & Strong) it was noted that hyperplastic conditions of the thyroid among small tropical fishes of the New York Aquarium occurred only in rare instances. Among approximately 400 species there were two examples of thyroid growths in the course of a period of observation lasting five years. These conspicuously enlarged goitres occurred in *Rasbora lateristriata* (Bleeker) and in *Heterandria formosa* Agassiz. They were sporadic forms of the disease and progressive in nature. Death occurred between six and eight weeks after the thyroid tumors were first observed. In order to study in greater detail the alterations in the diseased thyroid, a complete serial section of the entire head of a specimen of *Rasbora lateristriata* with thyroid hyperplasia has since been made. In addition, complete serial sections of four normal adult fishes of the same species, two male and two female, were prepared for purpose of comparison. The histologic observations on the normal and the hyperplastic thyroids are recorded and illustrated in the present paper.

A large part of the thyroid studies in fishes has been done on the Salmonidae, as these fishes are subject at times to a diseased enlargement of this gland, usually in the form of a benign hyperplasia, yet occasionally showing morphologic changes suggesting malignancy. A number of years ago, Gudernatsch (1911) described the normal structure of the thyroid gland in twenty-nine species of teleosts. By a systematic comparison of all these species this author found that there exists a wide variation in the thyroid gland of fishes, with a continuous series of transitions from one form to another. The thyroid gland of fishes, often invisible to the eye, is usually detected by microscopic examination. The actual position of the thyroid gland is described by Gudernatsch as lying below the floor of the pharynx, in the body of the tongue, between the gill arches, extending posteriorly near the origin of the third and fourth branchial arteries as they arise from the ventral aorta. The paired muscles of the sternohyoideus extend below the gland, while above the gland lie the bony and soft parts of the floor of the pharynx. The thyroid, therefore, lies in a relatively closed compartment whose separate structures are subject to con-

siderable variation. It is not surprising that the thyroid tissue itself was found to possess differences in size and distribution in individuals of the same species. For example, Gudernatsch found that in twelve weak-fish (*Cynoscion*), all differed in the extent and position of their respective thyroids.

It is well known that the thyroid gland of fishes cannot be regarded as a solid compact encapsulated organ as in higher vertebrates, but rather as a collection or grouping of follicles. The more densely arranged follicles lie in the neighborhood of the aorta or the branchial arteries particularly where these branches arise from the aortic stem. In Gudernatsch's studies, the thyroid follicles were most abundant in the region of the second gill arteries. The roots of the last gill branches seemed to have the least number of follicles. Usually the thyroid tissue lies ventral to the aorta, yet in some fishes dense clusters of follicles are located both dorsal and ventral to the aorta. Near the periphery, follicles are more commonly scattered in their arrangement.

It is of considerable anatomic interest that thyroid tissue in fishes follows a distribution along the main blood channels running between the heart and the respiratory tissue of the gills. It is believed that in the fish embryo, thyroid tissue lying originally between the first and the second gill branches later in development migrates in caudal, cephalic, and lateral directions to assume various other new yet permanent positions along the region of the aorta. This embryological migratory tendency along blood vessels exhibited by thyroid tissue may account for certain displaced thyroid follicles being found later in life in the domain of the more distant blood vessels of the gills. Such a distribution is not at all uncommon in the case of the trout under apparently normal conditions. The finding of normal thyroid tissue in the gills has offered considerable difficulty in interpreting the meaning of the larger hyperplastic thyroid masses involving gill structures when the thyroid gland as a whole responds to a stimulus causing a diffuse overgrowth.

At the time of Gudernatsch's paper on the normal thyroid in teleosts, a great deal of interest was manifest in the enlarged thyroid or goitre occurring in the trout. This disease made its appearance in this country and in Europe in epidemic and sporadic form. The lesions of fish goitre were extensively studied by Gaylord and Marsh (1914), Marine and Lehnhart (1910), Plehn (1902), Pick (1905), Pick and Poll (1903). The gross lesion makes its appearance as a pinkish globular swelling below the floor of the mouth, and later as a conspicuous swelling on the ventral surface in the region of the gills. Such goitres were known to regress, yet at times they showed a progressive course with a fatal issue. Various causative factors were suggested as important in their production, such as dietetic insufficiencies, lack of iodine, undetermined bacterial or virus infection from sluggish or contaminated water. As the disease in some of the fishes, as already stated, proved to be a progressive one and the goitre became a conspicuous tumor at times involving, microscopically, cartilage, bone, muscle or epithelium, some investigators attributed neoplastic features to this atypical form of growth, and the term "so-called carcinoma of the thyroid" came into descriptive use. It was pointed out that such thyroid tumors remained strictly localized. The few instances of associated isolated secondary growths described for the mandibular, gill or anal region, could be interpreted as embryologically displaced thyroid tissue in a state of hyperplasia. The evidence now points to the fact that nearly all types of fish tumors remain localized, irrespective of the histological characteristics, or the organ involved, and that secondary growths or metastases do not occur with the frequency among fishes that they do in the case of tumors in birds and mammals.

In our own investigation of the thyroid in *Rasbora lateristriata,* comprising four normal fishes, two male and two female, and the one case of thyroid hyperplasia, the entire head was fixed in 10 percent. formalin, and after decalcification, serial sections were prepared by the paraffin method. The stain used was hematoxylin and eosin.

The normal thyroid gland of this small "tropical fish" measuring about 3 cm. is invisible to the naked eye, but can be definitely located microscopically in the region anterior to the heart in close relation to the aorta. As is usual in the teleost, thyroid tissue does not form a compact gland. It consists in this fish of a very few small follicles, about 10 to 12 in number, strung along the main vascular trunk or its immediate branches. (Plate I, Figs. 1-4). The follicles are complete and do not communicate with each other. They are oval or circular in cross section and contain a small amount of eosinophilic staining colloid material, in places shrunken away from the lining epithelium as a result of the action of the fixative. The epithelium is a delicate one of a very low columnar or flattened type. The cytoplasm is clear, at times slightly vacuolated, while the nucleus of the cell is round or oval and not deeply stained. The epithelium is supported by fine fibrillar connective tissue showing here and there a narrow elongated nucleus. This fine fibrous tissue may send out processes uniting follicles to each other or to the extremely thin wall of adjacent blood vessels. No colloid droplets are visible in the epithelium or neighboring tissue spaces, blood, or lymph vessels. The larger thyroid follicles measure from 50 to 90 microns in diameter. There seem to be no clusters or nests of thyroid epithelium. No clues are suggested as to the manner of growth or regression of the thyroid follicle in this small fish. A few small blood vessels are found near thyroid tissue and an occasional small nerve trunk. No thyroid tissue was distributed in the substance of the gills. There was no essential difference between the male and the female thyroid.

Contrasting with the normal thyroid tissue, the hyperplastic thyroid growth offered a wide difference in appearance and distribution of its structural elements. The thyroid tumor itself measures 2.5 mm. in diameter, whereas the thyroid follicles in the normal fish occupy an area estimated as not much more than .1 mm. The goitre forms a somewhat irregular-shaped mass without a capsule. (Plate II, Fig. 5). The mass is composed in part of small compact thyroid follicles, in part of a diffuse continuous collection of larger follicles in various stages of distention with colloid. (Plate II, Fig. 6). The largest follicles measure as much as 550 x 190 microns. A rough estimate indicated that in the normal fish not more than 10 follicles were present in a cross section, whereas the thyroid tumor possessed perhaps as many as 3,000 follicles in a transverse section through its widest diameters. In the most compact part of the tumor, epithelial cells are very small with a small light-staining nucleus, while follicles distended with colloid are lined by very low columnar or flat cells. The irregular infolding of epithelium seen in human exophthalmic goitre is not present. Occasionally there is a papillary fold of epithelium supported by a delicate core of connective tissue which projects from the wall of a distended or cystic follicle into the colloid containing lumen. There are a few places where a point of communication exists between two adjacent cystic follicles (Plate III, Fig. 12). The rule is that where follicles are once formed, they remain globular and complete without any evidence of branching. For the most part follicles lie in contact, with a small amount of very fine connective tissue interposed. There is no evidence of fibrosis.

Whereas in the normal fish lymphoid cells are practically absent, in the hyperplastic specimen scattered collections of lymphoid cells are not uncommon. Such areas of lymphoid cells suggest the existence of an associated mild chronic inflammation. We found no inclusion bodies either nuclear or cytoplasmic.

Conspicuous in the diseased thyroid is the greatly increased vascularity. In all parts of the thyroid tumor are found small deeply engorged veins, representing a blood supply greatly increased over the normal. (Plate II. Fig. 6). There appeared to be no evidence that lymphatic vessels were correspondingly increased in number. The thyroid tumor does not show sufficient mitoses to indicate a rapid growth, nor are there changes suggesting degenerative processes or actual necrosis.

Infiltration of muscles, cartilage and bone is frequently encountered. (Plate III, Figs. 9, 10). The destructive assault upon gill tissues is particularly noteworthy (Plate II, Figs. 7, 8), as in the normal fishes no traces of thyroid tissue could be identified as occupying gill structures. In the caudal direction, the thyroid mass encroaches on the aorta near the heart (Plate III, Fig. 11). Here as in the gills, mechanical pressure caused by the thyroid mass might seriously impair the function of important vascular structures. It seems extremely doubtful that with such advanced replacement of gill tissues a complete regression and restoration to normal could be expected even if the necessary physiological conditions were ever re-established as, for example, by the experimental supply of sufficient iodine. Whether or no destructive invasion of normal tissues associated with the advancing thyroid growth represents in any sense a low grade of neoplasia is a matter of individual interpretation. Further studies of sporadic forms of thyroid growth in these small fishes would help to determine this point.

Summary.

The histology of the normal thyroid of *Rasbora lateristriata* is described and contrasted with an instance of massive hyperplasia of the thyroid occurring in the same species. The disease of the thyroid occurred in sporadic form. It was progressive and fatal in the course of two months. The excessive growth of the thyroid in this species of small fish destroyed and replaced gill structures, thus impairing the function of this important tissue.

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EXPLANATION OF THE PLATES.

Plate I.

Fig. 1. Section through the head of normal *Rasbora lateristriata* made at the level of the eyes. The small compartment containing thyroid tissue is indicated by the circle, *O*. M, floor of the mouth. x 15. Compare with the hyperplastic mass of thyroid seen in Fig. 5, Plate II.

Fig. 2. Four normal thyroid follicles, 1, 2, 3, 4, lying slightly dorsal to the aorta, A, near the origin of the branchial arteries, X and Y. x 125.

Fig. 3. Cluster of ten normal colloid-containing follicles dorsal to the aorta, A. x 200.

Fig. 4. Three normal thyroid follicles attached to a vein, V. A marks the aorta. x 500.

Plate II.

Fig. 5. Low power magnification of hyperplastic thyroid mass, T. x 13. The section is taken through the head at the level of the optic nerves. Compare with the normal thyroid area seen in Fig. 1, Plate I.

Fig. 6. Hyperplastic tissue with follicles of various sizes, with blood vessels at V and V′. x 175.

Fig. 7. Hyperplastic thyroid mass replacing gill tissue, G and G′. x 45.

Fig. 8. Thyroid follicles occupying gill structures. x 125.

Plate III.

Fig. 9. Hyperplastic thyroid invading muscle fibres, M. x 250.

Fig. 10. Hyperplastic thyroid infiltrating bony structures, B. x 125.

Fig. 11. Thyroid mass encroaching upon the aorta, A, near the region of the heart. x 58.

Fig. 12. Hyperplastic follicles with vacuoles in the colloid. Colloid material in follicles A and B appeared to be continuous through a break in the septum, S. x 250.

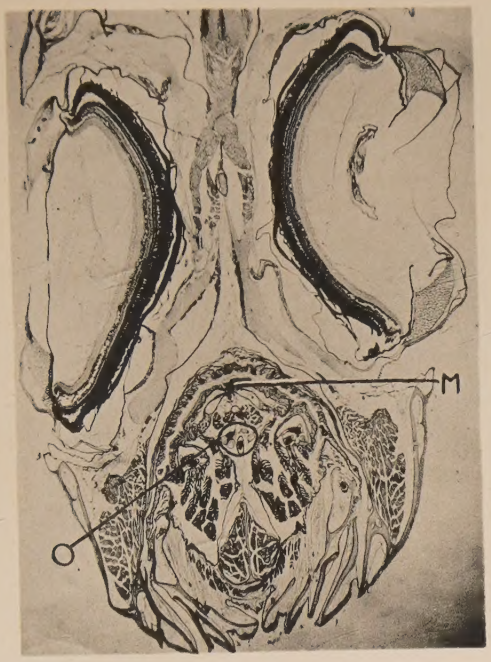

FIG. 1.

FIG. 2.

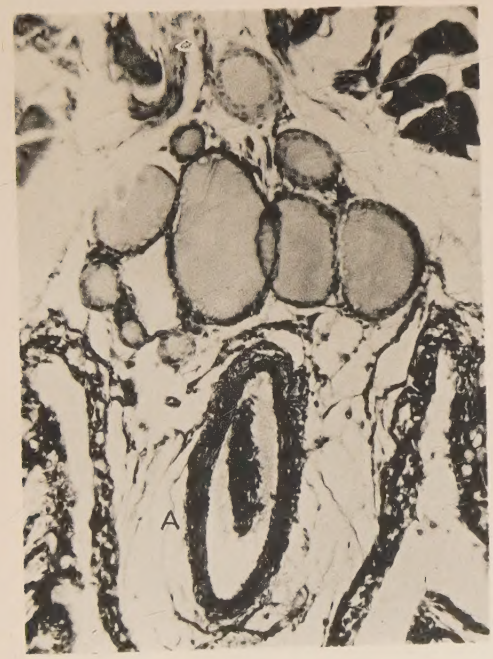

FIG. 3.

FIG. 4.

THE HISTOLOGICAL STRUCTURE OF THE NORMAL AND THE HYPERPLASTIC THYROID IN RASBORA LATERISTRIATA (BLEEKER).

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FIG. 5.

FIG. 6.

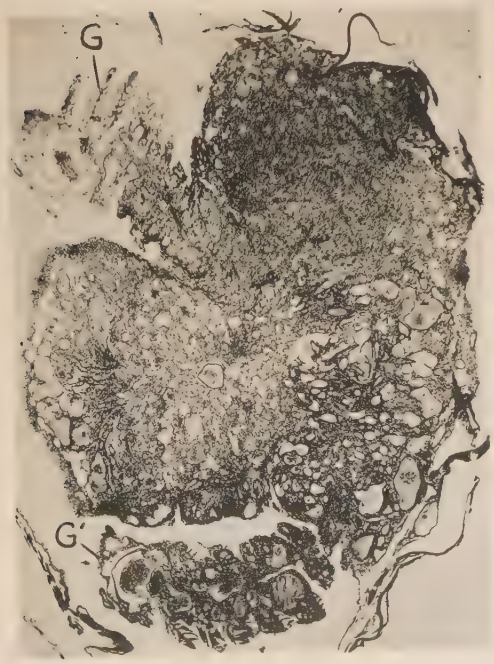

FIG. 7.

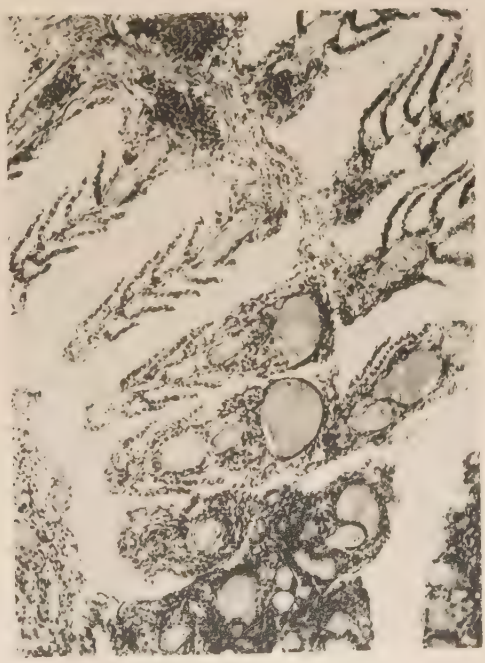

FIG. 8.

THE HISTOLOGICAL STRUCTURE OF THE NORMAL AND THE HYPERPLASTIC THYROID IN RASBORA LATERISTRIATA (BLEEKER).

22.

Lymphocystis in the Hogfish, *Lachnolaimus maximus.*

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(Text-figure 1).

One of several hogfish (*Lachnolaimus maximus*) received at the New York Aquarium in July, 1937, developed soon after arrival a number of small cutaneous tumors. With the use of a magnifying lens these tumors suggested lymphocystis disease, because they consisted of groups of small grayish-white colored nodules. These were distributed along the sides of the body, and on the dorsal, pectoral and tail fins.

The microscopic study of an excised piece from the border of a fin showed, both in total preparations and in the paraffin sections, that these lesions were clearly lymphocystis disease.

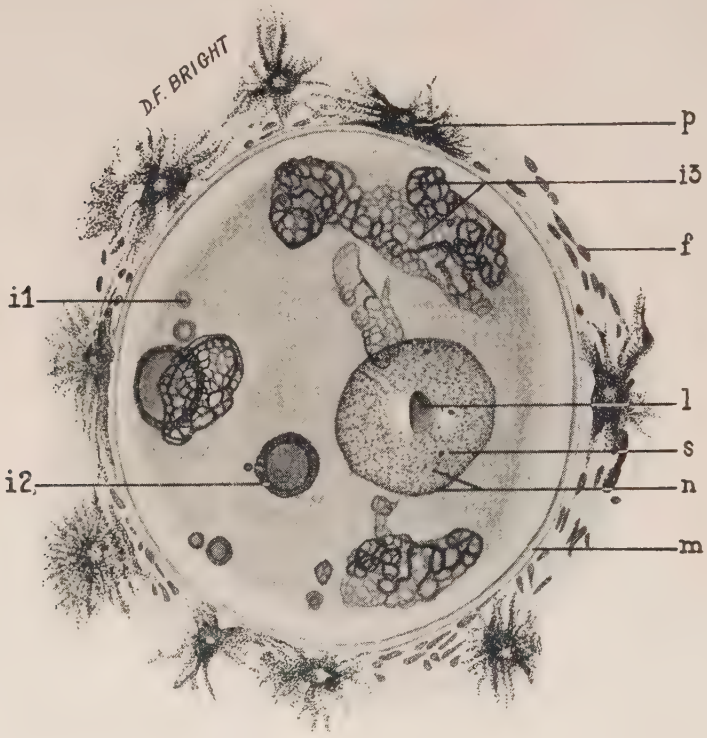
It is in the connective tissue of the fin host that the characteristic large lymphocystis cells were seen. These cells are similar to those noted by Weissenberg (1914, 1920, 1922) in two European species of fishes, the flounder (*Pleuronectes flesus*) and the ruffe (*Acerina cernua*), and more recently in America by Smith and Nigrelli (1937) in the angelfish (*Angelichthys isabelita*).

The lymphocystis cells have several conspicuous points of distinction. The cells, possessing only one nucleus, reach gigantic size; they are surrounded by a thick hyaline cell membrane; and finally, the cytoplasm contains very striking inclusion bodies which consist of a delicate network staining like the basophilic chromatin of the nucleus.

Text-figure 1 shows these characteristics in a relatively young lymphocystis cell, sketched from a total preparation stained with Delafield's hematoxylin. This oval-shaped cell measured 120 x 100 microns. It is surrounded by small connective tissue cells (f) and pigment cells (p). The enlarged nucleus (n) contains fine chromatin granules, one large nucleolus (l) and several smaller nucleoli (s). The cytoplasm, surrounded by the thick membrane, contains thirteen inclusion bodies of various sizes and form. These were sketched from different optical levels in relation to the nucleus. The dark bodies (i 2) lie in a plane above the nucleus, the

light gray (i 1) below the nucleus. Cell inclusions showing reticulated formation were chiefly demonstrable at about the level of the nucleus (i 3).

Because of the fact that there are numerous inclusion bodies, the lymphocystis cells in the hogfish more closely resemble those of the flounder. However, the reticulated bodies of the hogfish differ from those of the flounder lymphocystis cells of similar size in that they are of a more compact form. In the lymphocystis cells of *Acerina*, on the other hand, only one network of inclusion bodies surrounds the nucleus.



Text-figure 1.

Total preparation of lymphocystis nodule of hogfish, *Lachnolaimus maximus*. Stained with Delafield's hematoxylin. x 600. See text for explanation.

The smallest lymphocystis cells found in the tumors of the hogfish have a diameter of 120 microns, while the largest reach a size of 530 microns. The increase in size of the lymphocystis cells is usually accompanied by an increase in the number of inclusion bodies.

As to the interpretation of lymphocystis cells, Weissenberg (1914) has shown that they are not protozoa, but hypertrophied connective tissue cells of the host, probably stimulated to gigantic growth by the action of an intra-cellular virus.

It is interesting to point out here that the two species of fishes (*Angelichthys isabelita* and *Lachnolaimus maximus*) in which this disease has been recently found were collected at Key West, Florida.

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23.

Position of Wires in the Display of the Twelve-wired Bird of Paradise.

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(Text-figures 1-3).

In a recent description[1] of the display of the Twelve-wired Bird of Paradise [*Seleucides melanoleucus melanoleucus* (Daudin)], I made no mention of the position of the wires. This was because the wires of the bird under observation had become so worn and broken that they could not function normally. Since the time when the original notes were made (March, 1937), the bird has been through a complete molt and the wires are now perfect. It might be noted that this is a most unusual condition, since in most captive birds of this species, these appendages are broken off almost as soon as they develop.

The wires, which rise from the inner sides of the flank plumes, and appear to be specialized feathers of this group, emerge between the tips of the plumes, immediately beyond the end of the tail. Just after emergence, each curves sharply, six to the right and six to the left. The two inner wires, which are shorter and more delicate than the others, show less tendency to curve. When the bird is perching normally, the wires extend outward and slightly downward, apparently without strict regard to order.

In display, with the feathers of the abdomen tightly compressed and the flank plumes slightly expanded in the perpendicular plane, there appears to be muscular pull or tension, which causes the wires to rotate slightly. This rotation has the effect of bringing the wires into set alignment, the outer ones extending to right and left in the horizontal plane, at about the level of the bird's extended body, the curve causing a distinct forward tendency. This plan is carried out in the inner pairs, each extending outward, downward and forward, with the outward tendency decreasing in each pair as the center is approached. In the delicate central pair, the direction is almost entirely downward and forward. This leaves the twelve wires, approximately evenly spaced, extending forward, around and beneath the bird's body, none rising higher than its level.

The three text-figures on the following pages represent the positions of the wires when the bird is at rest, and when displaying. The figures were drawn from life by Mr. Joel Stolper.

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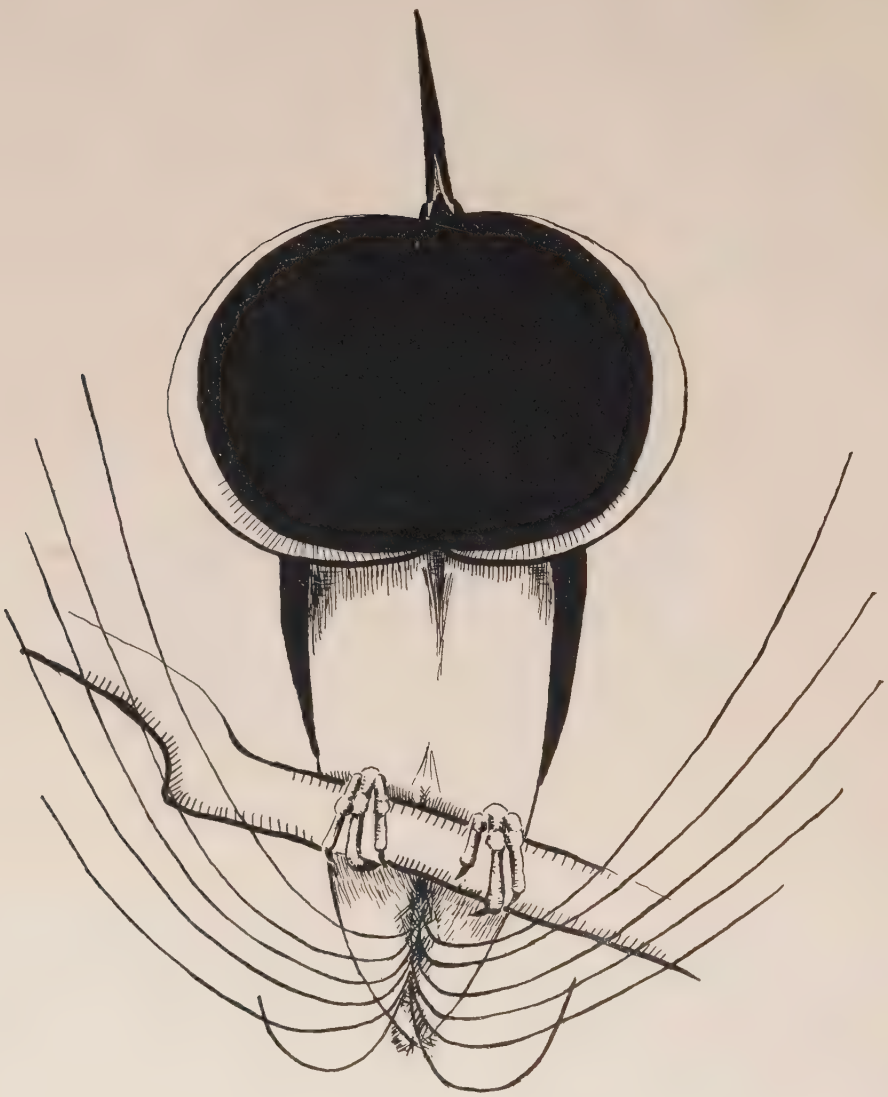
[1] *Zoologica*, Vol. XXII, Part 2, pp. 193-195, 1937.

Text-figure 1.

Position of the wires of the Twelve-wired Bird of Paradise, *Seleucides melanoleucus melanoleucus*, when the bird is at rest.

Text-figure 2.

Position of the wires of the Twelve-wired Bird of Paradise, *Seleucides melanoleucus melanoleucus,* in display. Side view.



Text-figure 3.

Position of the wires of the Twelve-wired Bird of Paradise, *Seleucides melanoleucus melanoleucus*, in display. Viewed from the front and below.

24.

Display of the Magnificent Rifle Bird.

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(Text-figure 1).

Although in captivity for over a year, our Magnificent Rifle Bird (*Craspedophora magnifica intercedens*) has not been observed in display until a month previous to this writing (October 25, 1937). The authors have seen the display performances of fifteen species of the *Paradisaeidae* and agree that this species, through its use of a markedly different method of execution, achieves an astounding, unexpected result, the most magnificent display so far observed for the entire group. Without any particular preparation the full display is entered into almost instantly, and whereas the long-plumed birds of paradise usually present an aesthetic, gentle waving of these pleasingly-colored plumes, here we have something entirely different, a decidedly virile display.

The display of the rifle bird has been adequately described by Selous.[1] After viewing the display, as given dozens of times, it is evident that a certain amount of variation can enter without materially changing the character of the performance. It is, therefore, deemed advisable to record the display as observed at the New York Zoological Park, calling attention to apparent discrepancies in or deviations from Selous' account.

After the first-observed display of our Rifle Bird, hours were spent awaiting subsequent performances. A week or more went by and we were unable to observe satisfactorily a complete display. Finally, a mounted female was borrowed from The American Museum of Natural History and placed just outside of the cage occupied by our male bird. The response was immediate and we (or, more strictly speaking, the stuffed female), were presented with a half-dozen displays in forty minutes.

There are but few preliminaries at the most, for while the bird occasionally precedes a display with characteristic vertical extensions of the head and neck, or a feigned indifference, as evidenced by active preenings and pecking of the feet, just as frequently a full display is achieved without any preliminary actions whatsoever. Whatever the procedure, the observer is always taken by surprise.

---

[1] Selous, Edmund C. Realities of Bird Life, 1927, p. 284-285.

There are two forms of the display, a long one and a short one. The short display was noted several times previous to the introduction of the stuffed female. Afterward, the long display was in vogue.

The Short Form of the Display.

The bird enters into either form of the display while sitting upright upon a slightly ascending branch. Frequently the display is preceded by a few abrupt, jerky, vertical movements of the head and neck. With this slight warning the wings are then thrown slightly forward and opened wide, to their fullest extent. Simultaneously, the neck is extended and the head moved to one side and brought to rest just behind the bend of the outstretched wing. The head is then moved from side to side, first in a period of about two seconds but immediately and regularly increased in speed until brought to an abrupt stop in the middle after about a dozen movements. This is a remarkably rhythmic performance and the last few movements are executed with such rapidity that it is practically impossible to determine their extent. Apparently they become shorter as the speed is increased. As the head movements cease the wings are folded and the display ended.

The Long Form of the Display.

At the start of the display the wings are usually opened so abruptly as to produce a rustling "plop." As the head is being moved from one side to the other the bird rises on his perch and slightly elevates (thereby relaxing) the extended wings. Simultaneously, as the head reaches the opposite side, the body is lowered on the perch and the wings are snapped back to their fully-extended position. This again produces a sharp, rustling sound which is, of course, repeated with every similar movement of the wings, throughout the performance. All these movements are repeated in unison, again and again. The wings-extended-head-to-the-side position for the first few movements is held rigidly for about three seconds. The time of movement then decreases to about three-quarters of a second and is maintained to the end of the display. During the longest and most regularly-executed of the displays observed the head was moved from side to side thirty-five times, punctuated, in perfect rhythm, by the rustling snap of the extended wings. No two displays are exactly alike, for they are varied by changing the regular, rhythmic beat of these coordinated movements. Action may be slowed down for a few seconds, then speeded up to the original beat. It has also been noted that at times, as the bird rises and falls on his perch, he may move up or down the perch but this appears to be due rather to incidental relaxing of the grip than to a definite dance motive.

Tail and plumes seem to play no important part in the performance. During the display the tail is held up in the rear in a fairly horizontal position. While it may be spread a trifle and moved slightly from side to side, such movements apparently serve only to assist the bird in maintaining his balance. The plumes extend around and below the body and serve principally to obscure its junction with the extended wings.

The foregoing merely describes the action of the display and gives but little indication of the remarkable effect secured. The observer is completely taken by surprise when, directly in front of him, the wings of the Rifle Bird are suddenly extended to form a dark concavity, the black inner surface of primaries and secondaries meeting perfectly, with no visible break, to their very tips. Then, too, because of the shortened outer primaries, the shape of the extended wings is unusual, almost bat-like but more symmetrical and graceful. In contrast to this velvety background-drop the scintillating green gorget now moves rapidly from side to side. The observer's

Text-figure 1.

Magnificent Rifle Bird (*Craspedophora magnifica intercedens*). **A.** Normal pose. **B.** Attitude at end of short form of display, just before wings are closed. Drawings by Joel Stolper.

eye is riveted to this oscillating dart of glowing green, so much so that he can see little else, and the display must be watched over and over again before he is able to note the other actions involved.

The effectiveness of the display seems to be dependent upon the quality and amount of light. The colors of the gorget are a more brilliant green on a dull, cloudy day and are set off to better advantage against the velvety black of wings and body. On a bright, sunshiny day the gorget does not appear to be green at all, but blue, and on such days the display is less striking. A small area on the inner tips of the flight feathers has a peculiar

glazed appearance and under certain light conditions reflects a light blue-green color. During the display a band of this color is thus shown along the lower edge of the deep black of the extended wings. This color area is indicated in the accompanying drawing.

Voice seems to pay no part in the display and, unlike Selous, we have never heard a vocal sound during dozens of closely-observed displays. We have never noted the mouth to be held open, and in this species the brightly colored lining of the buccal cavity would seem to possess no significance in connection with courtship display.

Between display periods our Rifle Bird frequently utters his loud call notes and likewise a pleasing, low-pitched version of the same, almost conversational in tone. While it has been stated that the call notes are never uttered more than a few times in succession, our bird has called a dozen times without a break.

25.

The Templeton Crocker Expedition. XII. Sergestidae (Crustacea Decapoda) from the Lower Californian Region, with Descriptions of Two New Species and Some Remarks on the Organs of Pesta in *Sergestes*.[1]

MARTIN D. BURKENROAD

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(Text-figures 1-12).

[Note: This is the twelfth of a series of papers dealing with the specimens collected on the Twenty-fourth or Templeton Crocker Expedition of the Department of Tropical Research of the New York Zoological Society; William Beebe, Director. For data on dredges, localities, dates, etc., concerning the capture of specimens treated in this paper, refer to the present volume of *Zoologica*, No. 2, pp. 33 to 46.]

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INTRODUCTION.

Of the six sergestids included in the present collection, two appear to be undescribed species; while two others, named forms which seem to be limited to the American Pacific, have never been completely diagnosed. I am deeply indebted to Dr. Beebe for the privilege of examining this material.

[1] Contribution No. 545, Department of Tropical Research, New York Zoological Society. Figures from camera lucida drawings by the author.

A list of sergestids recorded from the American Pacific but not included in the present collection is presented below:

1. *Sergestes inous* Faxon, 1893 and 1895; Hansen, 1919 (cf. Hansen, 1903, p. 69; and Illig, 1927, pp. 292-297). *S. profundus* Bate, 1888, p. 429, part (cf. Hansen, 1903, p. 69)?
2. *Sergestes edwardsii* Kroyer; Faxon, 1895, part (cf. p. 321 below. *S. oculatus* Kr., Faxon, 1895. *S. orientalis* Hansen, Cecchini, 1928?).
3. *Sergestes longispinus* Bate (the mastigopus of *S. cornutus* Kr. according to Hansen, 1922), Faxon, 1895.
4. *Sergestes longicollus* Bate, 1888, p. 422, part; Hansen, 1922, p. 92.
5. *Acetes binghami* Burkenroad, 1934.
6. *Lucifer orientalis* Hansen, Cecchini, 1928; Boone, 1930.

Sergestes H. M. Edwards.

In previous considerations of the genus, one set of structures of very considerable systematic importance has been neglected, namely the internal cephalothoracic organs briefly noted by Pesta, 1918 (quoted by Hansen, 1922, p. 21), in *S. corniculum, S. arcticus* and *S. vigilax*. As Pesta observes, the form of these structures [which may be termed the *organs of Pesta*] suggests for them a luminescent function; but whether this is actually the case I am unable to say inasmuch as varied manipulations of several living specimens of different species of *Sergestes* which possess the organs were not effective in inducing the production of light. If the organs are indeed luminescent, they seem to be the only ones known among crustacea which have been developed from endodermal tissue (cf. Dahlgren, 1916, p. 821: "They [rods of the photophores of euphausiids] thus stand, as one factor, in the evidence that these light cells . . . have, in common with most other light-cells, an ectodermal origin.")

The organs of Pesta seem from the study of dissections to be modified areas of the surface of the gastric gland (which is in almost all of the species of *Sergestes* a structure of relatively enormous size); these modified areas total altogether perhaps a tenth or twentieth of the bulk of the gland. The modified portions of the gland consist of groups of about 8 to 30 or more ventrally directed tubules, the terminal portions of which are constructed of a dense layer of columnar tissue bright Antwerp blue in color in the living animal. The dorsal, or more proximal, portions of the modified tubules are white and are more loosely constructed than the terminal parts, and merge (in the case of groups of modified tubules not pinched off from the body of the gastric gland) with tubules of more ordinary type, although tissue connected with the modified tubules seems to differ from that of the mass of the gastric gland by an increased density of granulation and in other ways. That part of the tunic of the gastric gland which covers the dorsal parts of the areas of modified tubules bears a dense layer of carmine chromatophores, and similar pigment surrounds the necks of the distal parts of the modified tubules themselves and lies between these tubules and the ordinary ones, so that each of the modified areas has in life the appearance of a fringe, cluster or spherule of blue (opaque yellow or white in preserved material) ellipsoidal bodies covered dorsally with a carmine cap and lying more or less near to or embedded in the translucent gastric gland.

The modified areas always include a pair at the anterior end of the gastric gland and almost completely separated from it, which seem the most highly developed of the organs. In addition to these there are always some modified tubules at the posterior end of the gland, variously organized as an undivided lateral and posterior fringe, a single posterior organ, a pair of posterolateral organs with or without an additional posteromedian area,

or even two posterolateral pairs plus an unpaired posteromedian one. The posterior organs also vary considerably from species to species in degree of consolidation. Finally, there may be an unpaired anteromedian area, and also a small pair of organs lying in the middle of the sides of the gastric gland. The modified areas or organs of Pesta of the anterior pair lie just above the dorsal wall of the branchial chamber, behind the dorsal end of the base of the mandible; and their ventrally directed uncapped surfaces are exposed to the exterior through the doubled but transparent integument overlying them. The organs at the posterior end of the gland are in part plainly exposed through the gap in the lateral musculature just above the branchial area of the thirteenth somite. The posteromedian, anteromedian, paired midlateral and anterior pair of posterolateral (when the posterolateral areas are subdivided) organs are however, when present, more or less invisible from the exterior (and were indeed overlooked by Pesta, who mentions only two pairs in *S. corniculum* which actually possesses ten distinct organs). The anteromedian area in particular, dorsally and posteriorly hooded by its pigment layer, faces through a layer of muscle into the densely pigmented posterior wall of the foregut.

Organs of Pesta appear to be present in all members of the genus other than the *S. mollis, S. tenuiremus, S. robustus* and *S. challengeri* superspecies of Hansen's "Group I." In available specimens of these latter four groups (which include altogether about half, or sixteen species of the genus), no portion of the gastric gland seems to be conspicuously modified. In compensation, however, numerous small complex photophores occur in the dermal layer of *S. challengeri* and related forms; and in *S. robustus* and its close relatives there are numerous small simple subcuticular bodies (Illig, 1914, p. 354[2]; Hansen, 1919, p. 10; Sund, 1920, pp. 11, 15, 18; Hansen, 1922, p. 21; and below, p. 324) the appearance of which suggests a luminous function particularly in fresh-caught material where (*S. crassus* Sund taken in the Straits of Florida during a recent expedition of the Bingham Oceanographic Foundation) these bodies appear as lenticular transparent structures invested on their inner sides by a layer of vermilion pigment. Surficial and presumably ectodermal or mesodermal photophores of these types, which have no structural relation at all to the endodermal organs of Pesta, seem to be absent in all of the species in which the latter occur.

As regards the systematic significance of the organs of Pesta, aside from their value as specific or superspecific diagnostics (which is in practice reduced by the fact that their elucidation requires a certain amount of damage to the specimen) their greatest interest lies in the possibility that their presence or absence marks the genus off into two natural groups the members of which seem in many other features as well to display more resemblance to one another than they do to the members of the other group. Without detailing the evidence or venturing at this time to modify Hansen's system, it may be stated that the distribution of certain characters among the species equipped with the organs of Pesta suggests that enlargement of the third maxillipedes may possibly have occurred independently in two different stocks, so that the form of these appendages may perhaps not be so significant of degree of relationship as Hansen's method of subdivision of the genus implies.

A more extensive consideration of the matters introduced above may be deferred until an exhaustive review of *Sergestes* has been completed. As will be shown on a subsequent page, the characters heretofore relied upon for separation of *Sergestes* from *Petalidium* are not diagnostic, and the major as well as the minor features of relationship within the subfamily therefore seem to be in need of further study.

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[2] Illig finds these bodies present in *S. robustus* Smith and in "*S. kroyeri* Bate." It is believed by Hansen, 1922, p. 91, that by *S. kroyeri* Illig refers to the *S. tenuiremus* Kr. of Hansen; however, no such rows of glandular patches seem to occur on the appendages of *S. tenuiremus*, and it would therefore appear that Illig refers, in part at least, to some other species.

Sergestes pestafer, sp. nov.

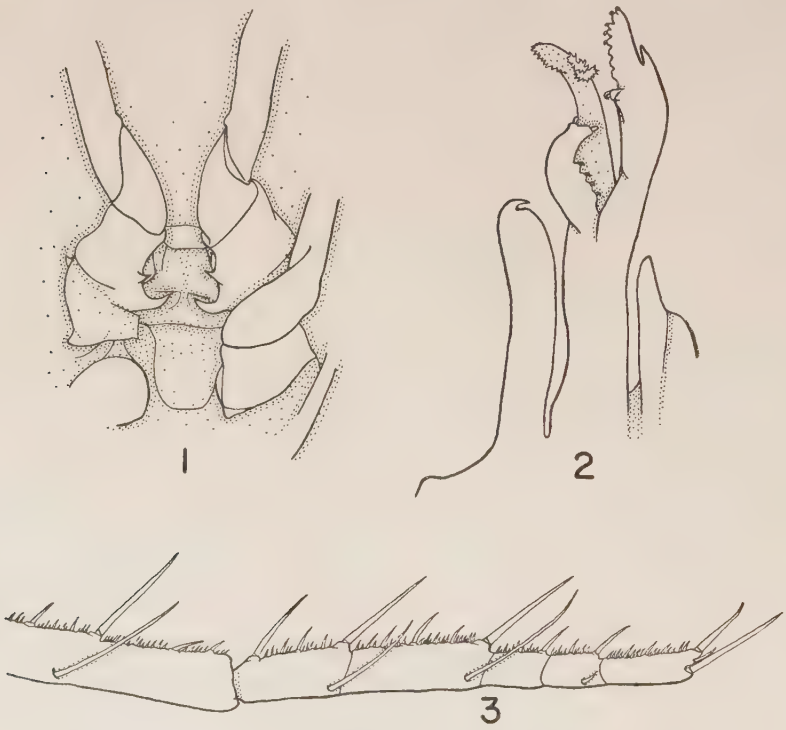
Text-figures 1-3.

Type: Holotype, Cat. No. 361,031, Department of Tropical Research, New York Zoological Society. Taken at Station 165 T-3; 20° 36′ N. Lat., 115° 07′ W. Long., 145 miles N. of Clarion Island, eastern Pacific; meter net at 500 fathoms; May 17, 1936. Paratype: Cat. No. 361,030, Station 130 T-1, 25° 17′ N. Lat., 113° 25′ W. Long., 68 m. WNW. of Cape San Lazaro, Lower California; meter net at 400 fathoms; March 28, 1936.

Range: Eastern Pacific off Lower California, the Cocos, and the Galápagos Islands. Midwater at levels of 400-600 fathoms or less, in depths of 500-2,000 fathoms.

Material: Two specimens were taken in the Pacific off Lower California in depths of 400-600 fathoms, as follows: *Station* 130: T-1 (1 ♂); *Station* 165: T-3 (1 ♀). Cat. Nos. 361,030, 361,031. Three males and three females from the collection of the Department of Tropical Research taken at *Arcturus* stations 74 and 86 have also been examined.

Dimensions and Sexual Condition: Female, adult, with ripening ovaries, of carapace 9.5 mm., total length 28 mm. Male, adult, of carapace 7 mm., total length 22 mm.



Text-figures 1-3.

Sergestes pestafer, sp. nov. **1.** Thelycum; adult ♀, TYPE, D. T. R. 361,030, x 18. **2.** Petasma (left endopod, anterior view of distal part); adult ♂ TYPE, D. T. R. 361,031, x 37. **3.** Third maxillipede (of the left side, median view of dactyl and distal part of propodus); as in 1, x 18.

Diagnosis: Organs of Pesta present, consisting of only five areas (a highly developed anterior pair almost completely isolated from the gastric gland; a well-developed ovoid posterior pair distinctly set off from the gland; and a small and less well differentiated posteromedian area). Supraorbital and hepatic spines present; telson with only a single pair of dorsolateral spinules, and with a terminal point. Distal article of antennular peduncle relatively long and slender in both sexes, although shorter than the basal segment. Third maxillipedes very long and basally much swollen; propodus much longer than dactyl and these two distal segments with many spines on one margin, a few only on the other; dactyl divided into five subsegments of which the inner margin of the ante-penultimate bears in males eight, in females eleven or twelve spines of all sizes. Ischium of the first and second legs with a spine on its outer margin; carpus of the first legs much shorter than the propodus; chelae of the second and third legs with fixed finger conspicuously shorter than the mobile one and palm with a longitudinal series of long setae; the two distal segments of the fifth legs setose on both margins. Ciliated portion of the external margin of the exopod of the uropods about one and one-half times as long as the unciliated part, and not separated from it by a tooth or spinule. Neck of the capitulum of the petasma long; processus uncinatus not reduced and with distal hook; processus ventralis not reduced and armed, in addition to a row of simple spinules, with one to three large stellate spines; lobus armatus curved medially and not extending to more than three-fifths the length of processus ventralis, its median margin armed with several hooked spinules; lobus terminalis bearing a small slender lobus internus closely applied to its median edge, and with the distal third of its lateral edge armed with a row of hooked spinules. The posteroproximal corner of the precoxa of the third legs of the females bears a conspicuous laterally directed spur; the coxa is armed on its posteromedian edge with two teeth, the distal of which is, although much smaller than the proximal, decidedly produced, so that the margin of the coxa proximal to it appears concave.

Remarks: *Sergestes pestafer* is very closely related to the *S. sargassi* Ortmann of Hansen, 1922, p. 148, and is distinguished from it only in a few minute but apparently rather constantly different details. In adults of *S. sargassi*, according to figures by Hansen and by Sund, 1920, p. 26, (sub *S. henseni* Ortmann) which are in agreement with North Atlantic specimens in the Bingham Oceanographic Collection, the inner margin of the antepenultimate subjoint of the dactyl of the third maxillipedes bears only four or five spines. Lobus armatus of the petasma reaches to two-thirds or more the length of processus ventralis; the latter bears five or more large stellate spinules; lobus terminalis is armed only with a single spinule at the tip, and lobus internus is relatively larger than in *S. pestafer* and divergent from lobus terminalis. The distal of the two pairs of projections arming the posteromedian edge of the coxa of the third legs of the female usually appears more like a sharp angle than a produced tooth, and the margin of the coxa proximal to it is more or less straight so that the portion of the margin lying between the tips of the two teeth often appears > -shaped rather than ⊃-shaped as in *S. pestafer;* the degree of development of the distal tooth in *S. sargassi* seems however to be somewhat variable. It may be noted that the supraorbital spines seem sometimes to be absent in *S. sargassi.*

The precise synonymy and the specific relationships of the *S. sargassi* group of species are in a state of some confusion, and it is particularly difficult to interpret the descriptions of Illig, 1927, of *S. pectinatus* Sund, *S. henseni* Ortmann, and *S. nudus* Illig (a form which as described for the second time, from adults, would seem to combine characters of the *S. edwardsii* with those of the *S. sargassi* superspecies in a very peculiar fashion). However, *S. pestafer* appears to be quite distinct from any of the material figured by Illig under these names. It seems possible that

the mastigopus of 7.8 mm. from north of the Galápagos, recorded as *Sergestes sargassi* Ortmann by Cecchini, 1928, p. 38, refers to *S. pestafer*.

No attention seems heretofore to have been bestowed upon the great resemblance in critical features of the *S. sargassi* to the *S. corniculum* superspecies, which is particularly marked as regards the peculiar form of the second and third chelae, as well as in the unique combination of various other characters. These two superspecies seem, indeed, to be distinguished from one another only as regards the form of the third maxillipedes, among characters of more than specific significance. In the present incomplete state of the resurvey of the genus, it appears possible that the *S. sargassi* superspecies and the *S. vigilax*, *S. edwardsi* superspecies may respectively be linked by way of the *S. corniculum* and the *S. atlanticus* to the *S. arcticus* superspecies, which last seems the nearest of all these forms to the group of superspecies which lacks the organs of Pesta.

Sergestes halia Faxon.

Text-figures 4, 5.

Sergestes halia, Faxon, 1893, p. 217.

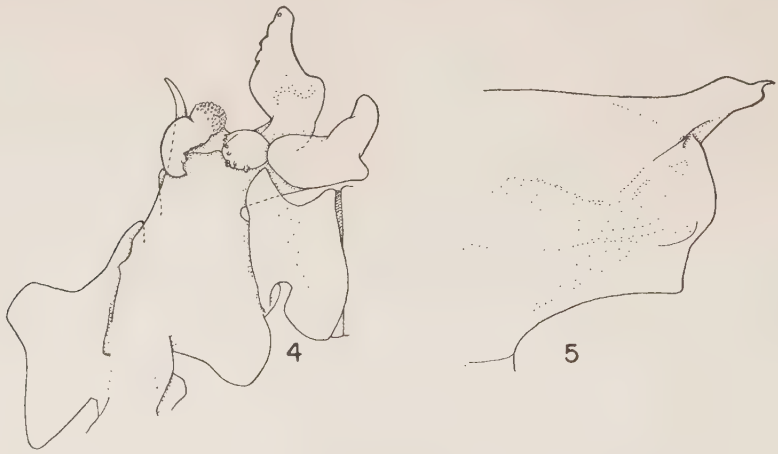
Sergestes edwardsi Kr., part, Faxon, 1895, p. 212.

Sergestes halia, Hansen, 1896, pp. 950, 960, 962.

Range: Gulf of Panama; off southeastern and southwestern Lower California. Midwater at levels above 300-500 fathoms.

Material: A total of 9 specimens (two being males) was taken off the southwest (Station 134) and the southeast (Stations 156, 158 and 159) coasts of Lower California, in 235 to 550 fathoms, as follows: Station 134: T-3 (1 ♂, 1 ♀); Station 156: D-2 (1 juvenile); Station 158: T-4 (2 ♀); Station 159: T-1 (2 ♀), T-2 (1 ♂), T-3 (1 ♀). Cat. Nos. 361,032, 361,033, 361,034, 361,035, 361,036, 361,037.

Dimensions and Sexual Condition: Females ranging in carapace length from 9.5 mm. to 15 mm., total length 25.5 mm. to 39 mm. Ripening ovaries are present in all of carapace 11 mm. or more. Males, adult, of carapace length 10 mm., total 28 mm. The juvenile specimen has a carapace length of 5.5 mm.



Text-figures 4 & 5.

Sergestes halia Faxon. **4.** Petasma (left endopod, anterior view); adult ♂, D. T. R. 361,032, x 26. **5.** Carapace (lateral view of anterior part); as in 4, x 13.

Remarks: In 1895 Faxon concluded that his *S. halia,* described in 1893, represented "large and mature individuals of *S. edwardsi,*" especially as Kroyer had recorded a variety of that species with rostrum larger than the typical. Faxon therefore identified his three specimens of *S. halia* with other smaller individuals taken by the *Albatross* which he referred to *S. edwardsi* Kr. In 1896, Hansen pointed out (p. 947) that Kroyer's "variety" of *S. edwardsi* is a species (*S. diapontius* Bate, to which, indeed, Illig, 1914, p. 365, suggests that Faxon's species may refer) related to *S. vigilax* and quite distinct from the type; and he proposed (p. 963) to revive *S. halia,* as a valid species closely related to *S. armatus* Kr. of the *S. vigilax* group.

The present material of *S. halia* seems to differ from *S. armatus* (according to Atlantic specimens of the latter in the Bingham Oceanographic Collection and to the figures by Hansen, 1922) most conspicuously as regards the form of the anteroinferior corner of the carapace, which is almost rectangular in *S. halia* instead of gently rounded as in *S. armatus* and related forms. The anterior part of the ventral margin of the carapace is naked, not setose as in *S. armatus.* The fairly conspicuous tubercle of the distomedian edge of the ocular peduncle of *S. armatus* is hardly indicated in *S. halia.* The third maxillipede, uropodal exopod, thelycum of the female, and various other features of *S. halia* seem to differ only very slightly from these structures in *S. armatus.* The petasma of *S. halia* presents a few minute but characteristic differences from *S. armatus;* thus, the distal part of lobus internus of the capitulum of the petasma extends much higher than does lobus connectens in large specimens of *S. halia,* and lobus terminalis is mitten-shaped instead of finger-like; both of these features are indicated in somewhat exaggerated form in Faxon's Plate LI, figure le (sub "*S. edwardsii*"). Of other petasmal differences, the armature of lobus terminalis is more extensive in *S. halia* and is placed upon the latero- instead of mediodistal edge; and lobus connectens bears only six or eight spinules upon its anterior face which are more or less concentrated toward the lateral side, instead of a dozen distributed over the entire anterior face.

The juvenile specimen of the present collection, perhaps better termed a late mastigopus, has eyes of a pale chocolate color, and a rostrum stretched out into a long slender tip, nearly one-third as long as the carapace; otherwise it nearly resembles the adults.

Hansen, 1922, p. 188, remarks that "Les données de Faxon (1895) sur l'occurence de *S. edwardsi* dans le Pacifique tropical oriental doivent être tenues pour extrêmement douteuses, surtout parce que le grand spécimen figuré par lui . . . doit appartenir à une espèce très différente mais encore inconnue." However, although the large specimens are indeed of another species, it seems probable that the smaller of the specimens recorded by Faxon as *S. edwardsii* are actually referable to this name inasmuch as, in sorting the *Arcturus* Sergestidae, a quantity of material which seems to pertain to *S. edwardsi* has been encountered.

Sergestes similis Hansen.

Sergestes similis, Hansen, 1903, p. 60; Illig, 1927, p. 310.

Sergestes atlanticus H. M. E., Bate, 1888, p. 320, part.

Sergestes atlanticus Rathbun, 1904, p. 145, part.

Sergestes similis, Schmitt, 1921, p. 19.

? *Sergestes articus,* Cecchini, 1928, p. 33.

? *S. nasidentatus,* Bate, 1888, p. 398; Hansen, 1896, p. 957; 1903, p. 62.

Range: Pacific off western North America, including Gulf of California. South Atlantic off southwest Africa; Pacific off Japan. Midwater above 145-500 fathoms.

Material: A single specimen was taken in the Gulf of California off Tiburon Island, in 500 fathoms, as follows: *Station* 148: T-4 (1 ♀). Cat. No. 361,038.

Dimensions and Sexual Condition: The specimen is a juvenile female of carapace 6.1 mm., total length about 21.6 mm.

Remarks: As regards shape of rostrum and relative size of branchiae, the present specimen agrees very well with the Japanese type as described by Hansen, 1903. The anterodorsal margin of the carapace, below the post-orbital ridge, is however nearly vertical and slightly concave, much as in *S. arcticus* Kr.; a difference from the type perhaps due to the smaller size of the present individual. The genital structures are quite undeveloped.

According to Schmitt, 1921, the "*Sergestes atlanticus*" 40 to 52 mm. in length from Pacific America recorded by Rathbun, 1904, are referable to *S. similis*. Rathbun (p. 145) has synonymized with her "*S. atlanticus*" the *S. pacificus* described by Stimpson, 1860, p. 45, from an individual "1.25 poll." in length taken in the western North Pacific. Hansen, 1922, pp. 52-53, who has evidently overlooked Rathbun's record of the lengths of her specimens, tentatively accepts her determination and synonymy, remarking that "Stimpson . . . établit *S. pacificus* sur des spécimens . . . mesurant 1.25 inches, soit environ 33 mm.; les plus grands spécimens de *S. atlanticus* me paraissent être un peu plus petits, mais je ne puis trouver aucune différence réelle entre la très brève description de Stimpson et *S. atlanticus* . . . Les specimens nommés par M. Rathbun . . . appartiennent certainement à la forme décrite par Stimpson." However, it seems to me improbable that *S. pacificus* was identical with the specimens described by Rathbun, and very possible that it does not refer to *S. atlanticus* either. Stimpson's description seems to exclude adult forms of all of the known species of *Sergestes* except *S. atlanticus* H. M. E. and *S. cornutus* Kroyer, since the third maxillipede of *S. pacificus* is not indicated to be enlarged; the lateral margin of the uropodal exopod is stated to bear a small tooth beyond its middle; and the third segment of the antennular peduncle is stated to be much longer than the second. It seems unlikely that the "dente praeorbitali" of Stimpson's description ("Carapax minus elongatus, rostro brevissimo conico resimo, et spina vel dente praeorbitali armatus; spina hepatica quam in *S. Frisii* magis posterior") refers to anything but a post-terminal rostral tooth (compare his description of *S. macropthalmus*, "carapax spina hepatica et spina supra-orbitalis armatus . . . Rostrum brevissimum, resimium, apice antrorsum flexum;" and that of *Sergia remipes*, "carapax valde elongatus . . .; spine hepatica nulla. Rostrum minutum spiniforme, acutum, curvatum, dorso dente vel spina armatum."); this feature, then, would exclude *S. atlanticus*. The remaining species, *S. cornutus*, has been recorded by Hansen, 1922, p. 53, from a locality very near that where *S. pacificus* was taken. If Stimpson's unit of measurement, "poll.," is intended to mean *inch*, his specimen of *S. pacificus* would be much larger than any of *S. cornutus* (a species still smaller than *S. atlanticus*) heretofore recorded; it seems possible, however, that for inch Stimpson would have used the common equivalent *uncia*, a twelfth part; whereas *pollex* is an alternative form of *digitus*, the one-hundredth part of an "org." or fathom (a term also employed by Stimpson) and the sixteenth part of a foot. In this case, Stimpson's "poll." would be equivalent to 18.5 mm. instead of 25.4 mm., and the specimen of *S. pacificus* would have a length of about 23 mm. instead of 32 mm., a size not too far in excess of that which *S. cornutus* sometimes attains. It seems of interest to note that Faxon (1895, p. 214) records "*Sergestes longispinus* Bate," a name which according to Hansen is referable to the mastigopus of *S. cornutus*, from the eastern Pacific.

It is possible that *Sergestes longicaudatus* Stimpson, 1860, p. 46, a late mastigopus or juvenile "0.75 poll." in length (14 mm. or 19 mm., depending on whether by "poll." Stimpson means a twelfth or a sixteenth of a foot)

taken in the middle North Pacific, may refer to *S. similis,* but as its description might also apply to several other members of Hansen's "Group I" no decision can at present be reached.

It seems possible that the "*S. articus* Kroyer" recorded by Cecchini, 1928, p. 33, from off the coast of Chile may refer to the present species rather than to *S. arcticus,* but no description of the branchiae of these two juvenile males is offered. Cecchini's figure of the petasma of a specimen 25 mm. in length indicates the general form to be similar to that in *S. arcticus.* The genitalia of adults of *S. similis* from the eastern or western north Pacific have never been described.

Sergestes phorcus Faxon.

Text-figures 6, 7.

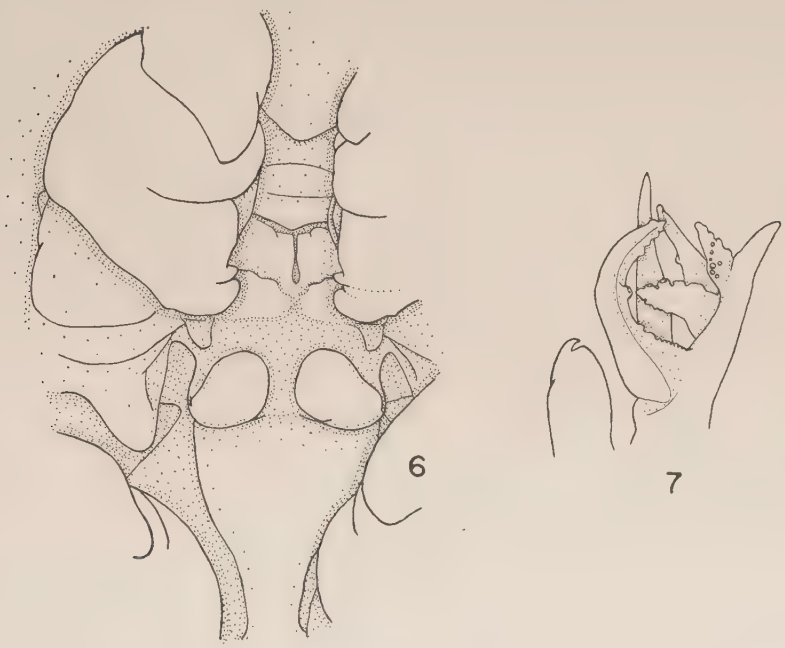
Sergestes phorcus, Faxon, 1893, p. 217.

Sergestes bisulcatus W. M., Faxon, 1895, p. 210.

Sergestes phorcus, Hansen, 1919, p. 5, part; Sund, 1920, p. 16; Hansen, 1922, p. 97; Boone, 1930, p. 121.

Range: Eastern Pacific off Galápagos Islands and Lower California; Gulf of Panama; Gulf of California. Midwater at levels above 242-550 fathoms in depths of 242-2,000 fathoms.

Material: A total of 4 specimens was taken in the Pacific off Lower California (Stations 134 and 165) and in the Gulf of California (Stations 139 and 148) in 300 to 550 fathoms, as follows: Station 134: T-3 (1 ♂



Text-figures 6 & 7.

Sergestes phorcus Faxon. **6.** Thelycum; adult ♀, D. T. R. 361,040, x 15. **7.** Petasma (left endopod, anterior view of distal part); adult ♂, D. T. R. 361,041, x 15.

juvenile); Station 139: T-4 (1 ♂); Station 148: T-6 (1 ♂ juvenile); Station 165: T-3 (1 ♀). Cat. Nos. 361,039, 361,040, 361,041, 361,042.

Dimensions and Sexual Condition: Female, adult with ripening ovaries, carapace 25 mm., total length 74 mm. Male adult, total length 57 mm.; juveniles, total length 29 mm.

Remarks: *Sergestes phorcus* is very closely related to *S. grandis* Sund, from which it seems to differ principally as regards petasma and thelycum. Differences in petasma have been fully described by Hansen, 1922, p. 97. The thelycum differs from that of *S. grandis* as figured by Hansen, 1922, plate V, fig. 3n, in that there is a sharply-cut transverse ridge, interrupted in the midline, just in advance of the posterior margin of the base of the third legs; and in that the portion of the twelfth sternite lying behind the level of the third legs bears a pair of subtriangular elevations which are quite well defined. The posteromedian corner of the coxa of the third legs of the female of *S. phorcus* bears a pair of blunt projections instead of a single tooth as in *S. grandis*.

In the present large female opaque patches similar to those which occur in other species of the *S. robustus* group and which are believed to be luminous organs are perceptible in considerable number. There is a row of ten of these patches along the inner margin of the antennal scale; two or three on the distal part of the exopod of the uropod, one at the base of the ischium in all five legs, one or two at the distal end of the ischium of the second and third legs, a row of seven in the merus of the first leg, of ten in the same joint of the third leg, and one patch in the base of the merus of the fourth leg.[3] There appear also to be less readily distinguished patches of the same sort on other parts of the body, as on the ventral surface of the sixth pleonic somite, on the sides of the pleon, between the pleopods, and on the precoxae of the pereionic legs. The patches are less numerous and less well-defined in the smaller specimens, but appear to occur in all.

Petalidium Bate.

Petalidium, Bate, 1881, p. 194; Hansen, 1922, p. 189.

Petalidium has in the past been considered to differ from *Sergestes* mainly in the smaller number and lesser degree of ramification of its gills and in the bifurcation of the processus ventralis of its petasma. However, in a Pacific American species described below which must undoubtedly be considered congeneric with *Petalidium foliaceum* Bate and *P. obesum* (Kroyer), the number of gills is the same as in *Sergestes*. The gills of the ventral series (the anterior arthrobranchs, after Burkenroad, 1937, p. 510), although with fewer rami and lamellae in the new *Petalidium* than in the least developed species of *Sergestes*, are yet considerably more richly branched in the new species than in the two species of *Petalidium* which have been previously described. The petasma of the new species is, most unfortunately, unknown; but it may be observed that in view of the slight but distinct subdivision of processus ventralis in *Sergestes mollis* Smith, described by Hansen himself (1922, p. 78), it is doubtful whether this feature can be considered as a clear generic distinction.

Although it seems best for the present to retain the accepted generic grouping (thus, Gurney, 1924, p. 95, finds the larvae of the two genera to differ), a re-evaluation of the relationship of *Petalidium* to *Sergestes* is undoubtedly required. Characters by which *Petalidium* may be distinguished from the *Sergestes mollis* superspecies are detailed on p. 327 below.

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[3] The occurrence of these patches on the legs of species of the *S. robustus* group, which has not been previously reported in print, was pointed out to me by Dr. F. A. Chace, Jr., of the Museum of Comparative Zoology.

Petalidium suspiriosum, sp. nov.

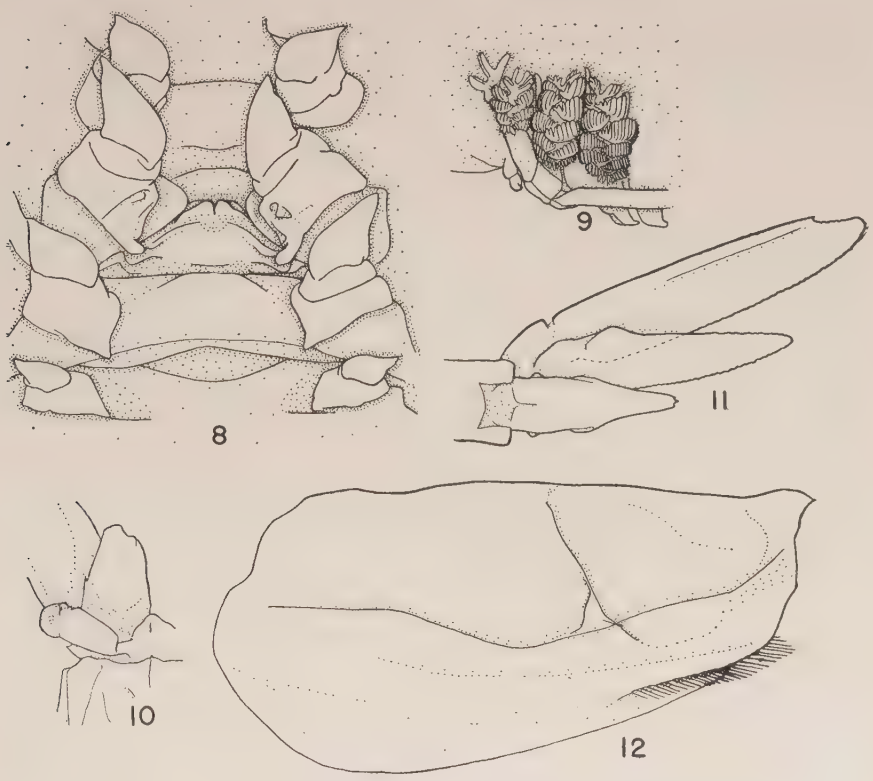
Text-figures 1-6.

Range: Definitely known only from the type locality in the eastern Pacific off Mexico, midwater at a level above 500 fathoms. Possibly off San Diego, California, depth 417 fathoms ("*Sergestes* sp. indet.," Rathbun, 1904, p. 146).

Material: A total of two specimens, both females, was taken 145 miles north of Clarion Island, Revillagigedo Islands, in 500 fathoms, as follows: Station 165: T-3 (2 ♀). Cat. No. 361,043.

Dimensions and Sexual Condition: Larger female apparently adult but with undeveloped ovaries, carapace 12 mm., total length 36.5 mm. Subadult female, carapace 8 mm., total length 26 mm.

Diagnosis: A podobranch and an arthrobranchial lamella are present on the eighth somite. An anterior arthrobranch, of up to thirteen rami placed alternately along the petiole, each of which may bear up to as many as twelve lamellae; and a lamella representing the posterior arthrobranch are present on somites IX, X, XI, and XII. A well developed anterior arthro-



Text-figures 8-12.

Petalidium suspiriosum, sp. nov. **8.** Thelycum; adult ♀, TYPE, D. T. R. 361,043, x 13. **9.** Branchiae (of somites XI-XIII); as in 8, x 6. **10.** Eye (of left side, dorsal view); as in 8, x 6. **11.** Telson and uropod (of left side, dorsal view); as in 8, x 6. **12.** Carapace (lateral view); as in 8, x 6.

branch consisting of nine rami bearing up to six lamellae each, and a small posterior arthrobranch of three rami of several lamellae each, are present on XIII.

The cervical sulcus is very distinct and is continued across the dorsum of the carapace although not here accompanied by the sharp carina marginal to it on the sides of the carapace. The cardiaco-branchial carina (and its anterior continuation, the antennal carina) is well developed. A minute hepatic spine is present. The postorbital carina is very weak and is unarmed. The rostrum is very short and fairly high with a pointed tip. It bears a rudimentary dorsal tooth in the smaller specimen. The telson narrows abruptly to a small terminal spine flanked by a pair of fixed lateral teeth. The integument is membraneous, smooth and shining, without reticulated pattern save that produced by subcuticular tissues in the antennal scales and uropods.

The cornea of the eyes is about one and one-half times wider than long; there is a well-developed tubercle at the base of the cornea on the inner side of the peduncle, and a minute projection further proximally. The distal segments of the antennular peduncles, the tips of the antennal scales, the third maxillipedes, and the legs except the fourth pair in the larger specimen, are all missing. The exopod of the uropod is a little less than five times as long as wide; the ciliated part of its external margin is somewhat less than one-sixth the length of the margin, and is separated from the unciliated part by a well-developed tooth.

The thelycum lacks an operculum; the medially incised posterior lip of the receptacular atrium thus overlies the anterior lip instead of being overlain by it.

Color in Formalin: Cornea of eyes pale chocolate-brown with dark internal area; median lobe of ocular somite with a black fleck. Mouthparts carmine with golden-brown setae; stomach and oesophagus deep carmine; leg-bases and ridges of pereionic sternites pale vermilion. Gastric gland cream-colored. Otherwise white (transparent-translucent in life?). The extreme oiliness of the gastric gland seems worthy of mention.

Remarks: *Petalidium suspiriosum* appears to differ from all other described material of the genus in that the rami of the anterior arthrobranchs of IX-XII may bear as many as twelve lamellae, instead of "généralement cinq ou six par série" (Hansen, 1922, p. 189); and particularly in that there are two gills instead of one on XIII, of which the anterior is large and well developed rather than "rudimentaire ou rien."

P. suspiriosum differs further from *P. obesum* Kr. as described by Hansen, 1922, in the following particulars: In *P. obesum* the integument is stated to be "en outre réticulé;" the cervical sulcus is scarcely visible; both supra-orbital and hepatic spines are absent; there is no second tubercle proximal to the well-developed one at the distal end of the inner margin of the ocular peduncle; and the lips of the receptacular atrium of the female are covered by a well-developed operculum with convex posterior outline. It may be noted that in the lack of an operculum the thelycum of *Petalidium suspiriosum* resembles that of *Sicyonella* and of *Acetes* (Burkenroad, 1937, p. 509).

With regard to the other named species of the genus, *P. foliaceum* Bate, the available information is somewhat fragmentary and is so contradictory as perhaps even to indicate the existence of still another species of *Petalidium*. According to Bate, 1888, p. 349, Hansen, 1903, p. 54, and Illig, 1914, p. 373, the thirteenth somite lacks a gill completely in the eight adult or subadult specimens of *Petalidium* examined by these authors, all of which had been captured in subantarctic waters. Hansen, 1903, suggests that certain larval specimens of *Petalidium* including the type of *Sergestes obesus* Kroyer, in which the rudiment of a gill is present on XIII, may represent a species distinct from the adults then known in which this gill is always

absent; subsequently, Hansen (1922, p. 193) finds frequently but not always "une branchie rudimentaire" on XIII among twenty specimens taken in the temperate or tropical North Atlantic which he consequently distinguishes from *P. foliaceum* under the name *P. obesum* (Kroyer). Unfortunately, Hansen characterizes *P. foliaceum* only with the somewhat indefinite remarks that by reason of the absence of the rudimentary gill of XIII in some individuals of *P. obesum,* the presence only of this rudiment "peut compter comme caractère specique positif;" and that the figures of the petasma of subantarctic specimens, presumably of *P. foliaceum,* by Illig, 1914, and Stebbing, 1914, are in substantial agreement each with the other but different from Hansen's own figures of *P. obesum* "par plusieurs particularités".

Since the publication of Hansen's discussion, Illig, 1927, p. 283, has published a figure of the petasma of a specimen of *Petalidium* taken in the South Atlantic not far north of the previous records of *P. foliaceum,* which agrees very well with Hansen's figures of *P. obesum.* Illig, who seems not to have been aware of Hansen's later studies, and who does not discuss the branchial or carapacic characters of this particular male, reports his specimen as *P. foliaceum* without remarking that the petasma differs from that which he had previously figured under the same name. This difference between two figures referred by their author to the same species seems a good demonstration that two forms of petasma actually occur in the material of *Petalidium* previously known. The chief difference between these two forms of petasma seems to be that the distal, posterior lobule of lobus armatus of pars media is in *P. obesum* much smaller and less heavily armed than is the proximal, anterior lobule; whereas in *P. foliaceum* the distal, posterior lobule is the larger and more heavily armed of the two branches.

According to Bate, and to Hansen, 1903, p. 55, the *Challenger* specimens of *P. foliaceum* have neither hepatic nor supraorbital spines; the cervical sulcus is well developed; and the ocular peduncle sometimes bears two tubercles on its inner margin. According to Illig, 1914, the carapace of his specimens of *Petalidium,* which from his figure of the petasma seem referable to *P. foliaceum,* bears a well-developed cervical sulcus and (in contrast to Bate's and Hansen's specimens) both hepatic and supra-orbital spines; the ocular peduncle has two tubercles on its inner margin. Stebbing's description (1914, p. 284) of a specimen which by its petasma seems referable to *P. foliaceum* takes no account of the carapacic features or of the branchial formula, but his undetailed figure seems to indicate a well-developed cervical sulcus, and he states that the ocular peduncle bears two tubercles.

The above contradictory or incomplete accounts of *Petalidium foliaceum* seem to require, in the absence of information as to the female genitalia of this species or of the petasma of *P. suspiriosum,* that the distinction of these two forms must for the present rest entirely upon the difference in branchiae, which however seems so great (XIII with two gills in *P. suspiriosum;* without any in *P. foliaceum*) as to provide an excellent diagnostic.

Petalidium suspiriosum displays considerable superficial resemblance to *Sergestes mollis* Smith and *S. inous* Faxon, from which, however, it can instantly be distinguished by the quite different appearance of its anterior arthrobranchs which are composed of fewer but larger rami, by the presence of an hepatic spine on the sides of its carapace, by the absence of more than one pair of lateral spinules on its telson, by its shorter but larger eyes with distomedially tuberculate peduncle, etc.

It seems possible that "*Sergestes* sp. indet." of Rathbun, 1904, p. 146, and Schmitt, 1921, p. 20, a female of about 38 mm. taken in 417 fathoms off San Diego, California, may refer to *Petalidium.* The extreme mutilation of the specimen, which is "without maxillipeds or trunk-legs," and which "resembles *S. mollis* Smith" but possesses "a minute hepatic spine," is suggestive of the present species.

LUCIFER Thompson.

Lucifer typus H. M. Edwards.

Leucifer typus, H. M. Edwards, 1837, p. 469.

Lucifer typus, Hansen, 1919, p. 53; Cecchini, 1928.

? *Lucifer acestra,* Faxon, 1895, p. 214.

Range: Atlantic; Indo-Pacific; eastern North Pacific including Gulf of California. Surface (and midwater?).

Material: Two specimens were taken in the mouth of the Gulf of California, in 400 fathoms, as follows: Station 159: T-2 (2 ♂). Cat. No. 361,044.

Dimensions and Sexual Condition: Both specimens are sexually mature males measuring about 9.6 mm. in total length.

Remarks: No differences from Hansen's description are perceptible. It seems worth remarking that the scarlet spherule which occurs in the telson of *L. typus* and *L. faxoni* Borradaile of the genus at least, seems from the dissection of formalin material to be not a simple pigment spot but a ball of cells invested with a tunic of chromatophores.

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26.

Deep-sea Fishes of the Bermuda Oceanographic Expeditions. Family Serrivomeridae. Part II: Genus *Platuronides.*[1]

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(Text-figures 1-14).

INTRODUCTION.

For detailed data in regard to nets, locality, dates, etc., concerning the capture of the deep-sea eels treated in this monograph, refer to *Zoologica,* Vol. XIII, Nos. 1, 2 and 3 and Vol. XX, No. 1, pp. 1-2. For physical data, methods of measurement and definitions of growth stages, see *Zoologica,* Vol. XVI, No. 1. The genus *Serrivomer* has been discussed in *Zoologica,* Vol. XX, No. 3. A definition and discussion of the family Serrivomeridae will be found at the end of the present paper (p. 346).

The drawings in the present paper are the work of George Swanson.

Genus ***Platuronides*** Roule and Bertin, 1924.

Generic Characters (Adults): Snout less than half length of head; gradually tapering, not sharply constricted in front of eye; vomerine teeth conical or compressed, widely or not widely separated but not forming a ridge as high or as continuous as in *Serrivomer.* Trunk decreasing gradually in height and thickness from shoulder to tail; no nuchal constriction; no caudal filament; jaws strong, the lower slightly the longer; maxillary and mandibular teeth small, pointed, in one to six rows; structure and arrangement of vomerine teeth various, as mentioned above; nostrils tubular or non-tubular; pectorals vestigial; dorsal beginning well behind pectorals and continuing to tip of the tail; anal origin immediately behind anus, at a distance about mid-way between pectoral base and dorsal origin, and continuing to the end of the body; posterior portions of dorsal and anal fins relatively rigid with densely crowded rays which form, with the rudimentary true caudal fin, a semi-rhombic pseudo-caudal; about 50 anal rays in the last 3.5 per cent. of the total length of the fish, and more than 50 rays occupying a space per ray of less than one-tenth of 1 per cent. of the total length; lateral line without pores.

Young transitional adolescents (elvers) of *Platuronides,* in which the specialized development of dorsal and anal rays is not yet conspicuous, can be told at a glance from *Serrivomer* of similar length by the compression of the posterior part of the body, as opposed to its roundness in *Serrivomer,*

[1] Contribution No. 546, Department of Tropical Research, New York Zoological Society. Contribution, Bermuda Biological Station for Research, Inc.

and by the lack of silvery pigmentation, which is pronounced in immature *Serrivomer.*

Discussion: Three species of *Platuronides* have been described, all from Bermuda and the Bahamas, two of them having been taken by the Bermuda Oceanographic Expeditions.

Platuronides danae, described from a single 486 mm. specimen taken in the Bahamas, and since taken off Bermuda by the present expeditions, is a perfectly distinct species characterized by having the vomerine teeth all conical, widely separated and set in a single line, and by having the anterior nostril tubular.

Platuronides ophiocephalus and *P. acutus,* however, both described by Parr in 1932 from single specimens taken off Bermuda, may very possibly prove to be synonymous for the following reasons: The two species differ from each other chiefly in the dentition, which, in *P. ophiocephalus,* consists of fewer teeth more regularly arranged than in *P. acutus;* however, the type specimens measured, respectively, 632 mm. and only 220 mm. in length, and our studies on the development of the teeth in *Serrivomer* (see *Zoologica,* Vol. XX, No. 3) have shown similar and equally radical differences in the teeth of specimens of different sizes; furthermore, the largest specimens of *P. acutus* in the present collection are smaller than the type and, though plainly referable to this species, show still more teeth, even less regularly arranged. Again, the differences in proportions, including the major one of the width between sphenotic prominences ("less than 20 per cent greater than the interorbital width" in *P. ophiocephalus,* and "about 40 per cent greater" in *P. acutus*) also may easily be growth characters; it is more than 40 per cent greater in our specimens which, as has been said, are all smaller than the type. As a final, but slight, indication of synonymy, it may be mentioned that all of the leptocephali of this genus taken by us off Bermuda plainly belong to only the two species, *P. danae* and *P. acutus.* Definite synonymy, however, cannot be established until specimens intermediate in size between the two type specimens have been secured.

An additional specific character found in the present specimens is the vertebral count, about 165 to 170 in *P. danae* and about 153 to 158 in *P. acutus.*

Larvae: The leptocephalus of *Platuronides* resembles that of *Serrivomer,* having the same type of snout, total number of myomeres (about 153 to 168) and the same posterior position of the anus. In addition, it metamorphoses at about the same length, the largest larvae of both genera being 61 and 62 mm. long. *Platuronides* leptocephali differ, however, from those of *Serrivomer* as follows:

1. There are 102 to 125 pre-anal myomeres, not 89 to 97 (as in *S. beanii*).

2. The younger larvae (between 18 and 40 mm. in length[2]) are more slender than corresponding stages of *Serrivomer,* the maximum depth, excluding gut and finfolds, being contained 10 to 17 times (6 to 10 per cent.) in the length, instead of 7.8 to 8.3 (12 to 13 per cent.). The extreme larval range of depth is 8.4 to 17 (6 to 12 per cent.) in the length in *Platuronides,* and 7.8 to 9.6 (10.4 to 13 per cent.) in *Serrivomer.*

3. Pigment spots are present only on either side of the midline far back on the tip of the tail and, farther forward, in a single row, below the midline, where not more than half a dozen, well separated, are scattered before and behind the level of the anus. The anterior five of these chromatophores are quite constant in position, occurring at or near the 96th, 104th, 113th, 122nd and 130th myomeres; they may be designated by the letters A, B, C, D and E, respectively. Some or all of the series, however—es-

[2] No specimens shorter than 18 mm. were taken.

pecially chromatophore A—may be minute or lacking, particularly in large specimens; also it frequently happens that a chromatophore is visible on only one side of the body; a final variable factor is the distance of the pigment spot from the midline.

Unlike the arrangement in *Serrivomer*, chromatophores are entirely lacking both along the base of the anal fin and in oblique series outlining the myomeres.

Leptocephali of *P. acutus* in the present collection measure between 18 and 62 mm. in length, while those of *P. danae* range from 31 to 61 mm. Within these limits, the following key is applicable:

Pre-anal myomeres 108 to 115[3]; anus between chromatophores C and D, or, in smallest specimens, B and C..... *P. acutus*

Pre-anal myomeres 122 to 125; anus between chromatophores D and E..... *P. danae*

Platuronides danae Roule and Bertin, 1924.

SPECIMENS TAKEN BY THE BERMUDA OCEANOGRAPHIC EXPEDITIONS.

7 specimens; May to September, 1929 to 1931; 50 to 1,000 fathoms; from a cylinder of water 8 miles in diameter (5 to 13 miles south of Nonsuch Island, Bermuda), the center of which is at 32° 12′ N. Lat., 64° 36′ W. Long.; standard lengths from 31 to 488 mm.

SPECIMEN PREVIOUSLY RECORDED.

1 specimen; about 350 fathoms; off Bahama Islands; length 486 mm.

DESCRIPTION OF ADULT.

(Text-figs. 1, 2C).

(Based upon the description of the type, and upon the 488 mm. Bermuda specimen).

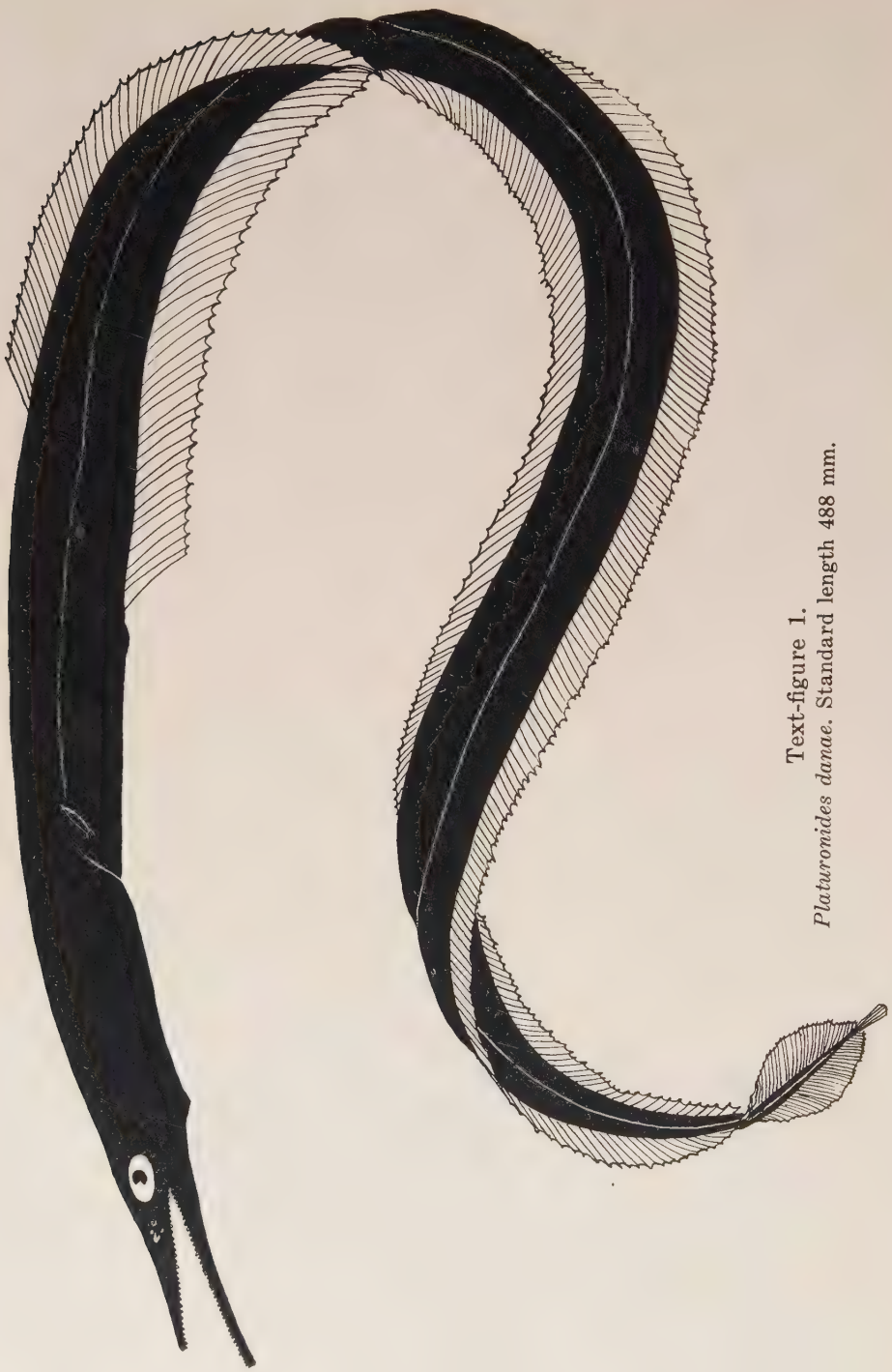
Color: The fresh Bermuda specimen was dark bronze, finely dotted with black specks. Of the type specimen, Roule and Bertin write (1929, p. 50): "La coloration est noirâtre, sans reflets irisés, avec le ventre plus foncé que le dos. Les iris sont bleuâtres." It is probable that these notes were made upon the preserved specimen, in which case the lack of iridescence is easily explained. On the other hand, the difference may be sexual: the Bermuda specimen is a male; the sex of the type is not stated.

Proportions: Maximum depth (immediately behind head) in length 33.5 to 35 (2.9 to 3 per cent.); head in length 6.1 to 6.3 (16.4 to 16.5 per cent.); eye (horizontal) in head 11 to 12.4 (1.3 to 1.5 per cent. of length); snout in head 3.4 to 3.45 (4.7 per cent. of length); lower jaw slightly longer than upper; vomer projecting less than one-sixth length of snout beyond tip of maxillary; interorbital width in length 69 to 70 (1.43 to 1.44 per cent.); intersphenotic width in length (Bermuda specimen only) 51 (2 per cent.); intersphenotic width 26 per cent. greater than interorbital width; snout to dorsal origin in length 2.9 to 3 (33 to 34 per cent.); snout to anal origin in length 3.75 to 3.8 (26 to 27 per cent.).

Nostrils: Anterior nostril tubular.

Teeth: (Text-figs. 3-5). The maxillary teeth of the type specimen are described (*loc. cit.* p. 49) as occurring in a single row in each ramus, and as being quite long and pointed, their length equalling about one-eighth the

[3] Except in 18 mm. specimen, which has only 102 pre-anal myomeres, though typical in every other way.



Text-figure 1.
Platuronides danae. Standard length 488 mm.

vertical diameter of the eye; about 50 maxillary teeth are shown in the figure in each ramus. Before clearing and staining, the teeth of the 488 mm. Bermuda specimen agreed very well with this description. Afterwards, however, it was evident that, in addition to the 39 to 42 teeth in a row in each maxillary ramus, there is an outer series of minute denticles, in an irregularly double row.

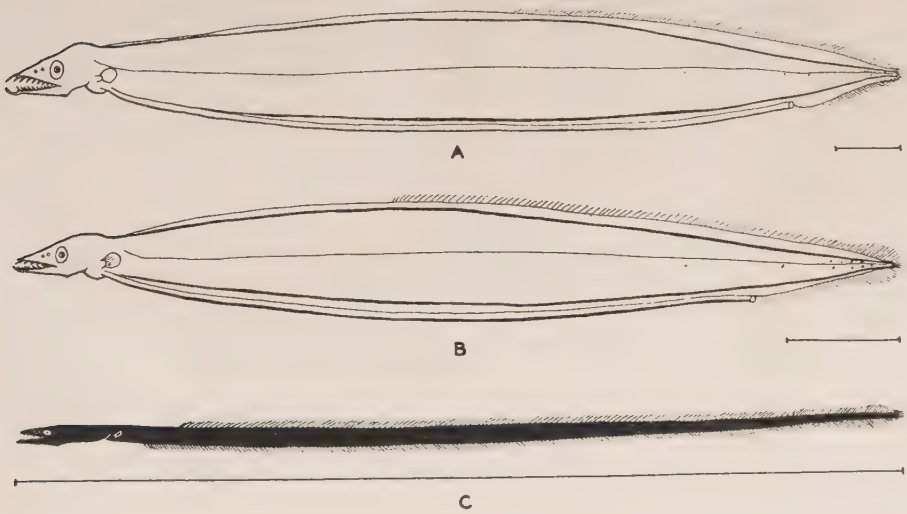
The mandibular teeth, not mentioned in the type description, number 39 to 44 in each ramus in the Bermuda specimen, all except three or four being set in a practically straight line on the outer margin of the jaw. The top of the latter bone is broad and flat, and along its inner margin, well separated from the row of teeth, is a row of very minute denticles, broken by several full-sized teeth in each jaw. This row is evidently the remains of a regular row of teeth such as is found in *Serrivomer*. Traces of a third, median row are also present. The full-sized mandibular teeth are twice as long as the longest teeth in the maxillary and, like them, are conical with the tips slightly recurved.

There are 16 teeth on the vomer, arranged in an irregularly single line. The anterior nine are relatively small and close set, and similar to those of the maxillary in size and shape. The posterior seven, however, representing the vomerine ridge of *Serrivomer*, are broad, flat, as long as the mandibular teeth, and well separated from each other. There are a number of marks of lost teeth on the vomer.

Fins: Pectoral rays 6 or 7, equal in length to vertical diameter of eye, inserted at upper angle of branchial clef. Dorsal rays 170, anal rays 166 in type, about the same in Bermuda specimen.

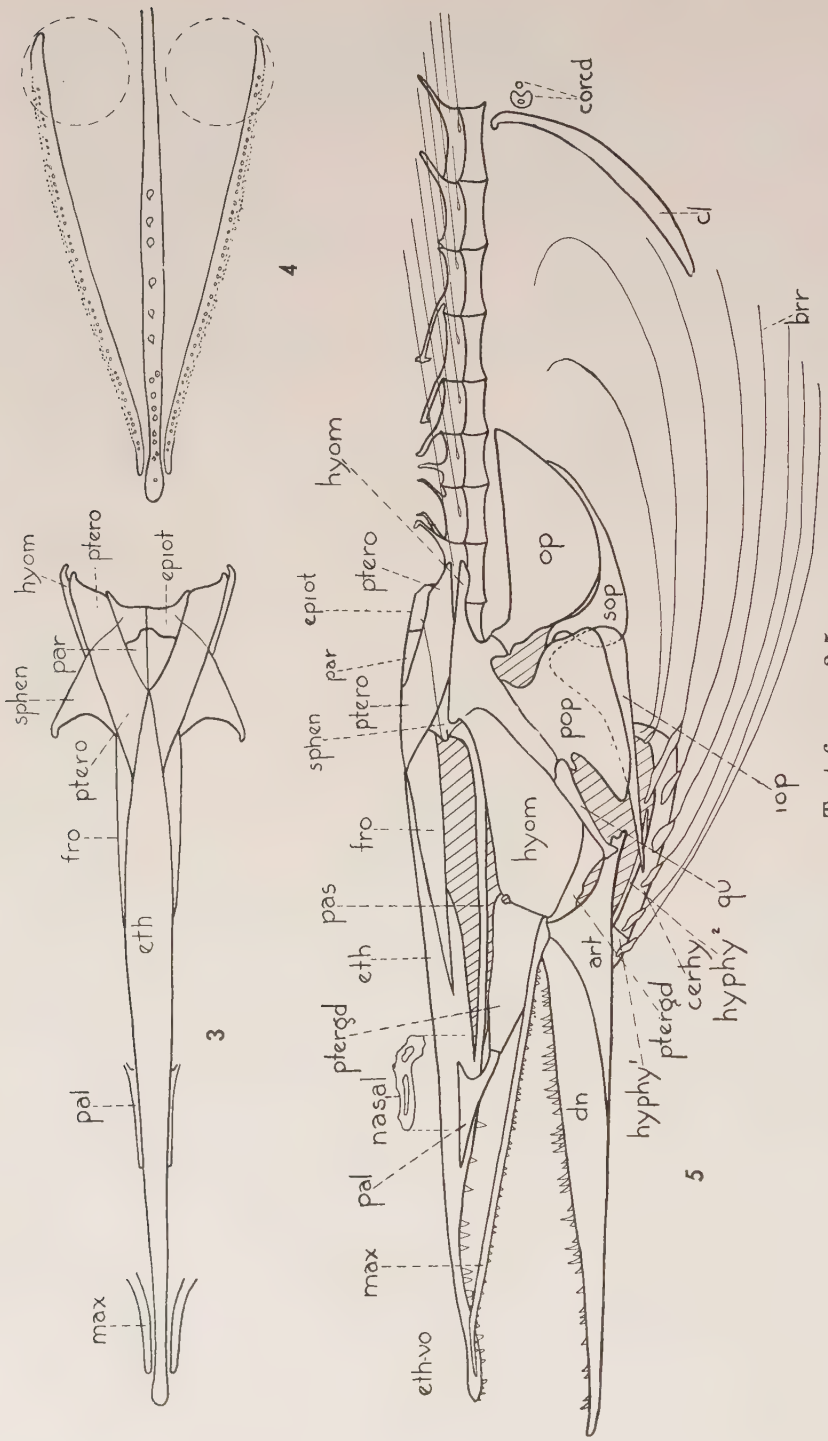
Osteology: (Text-figs. 3-7). The entire skeleton of *Platuronides danae*, as observed in the 488 mm. Bermuda specimen, is very similar to that of *Serrivomer*, both in relative positions of the bones and, in most cases, in their forms and proportions. The following differences may, however, be pointed out:

1. The skull of *Platuronides danae* is both longer and broader than that of *Serrivomer*. This is due chiefly to the greater extent of the pterotics.



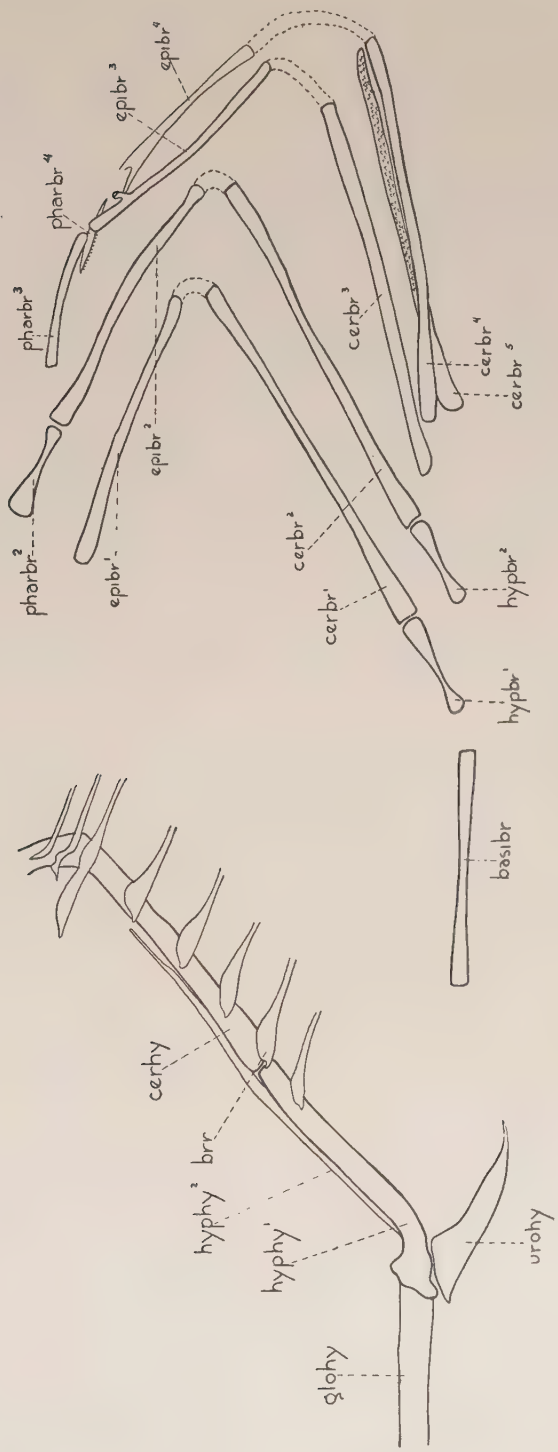
Text-figure 2.

Platuronides danae. **A**, larva, 36 mm.; **B**, larva, 61 mm.; **C**, adult, 488 mm.



Text-figures 3-5.

Platuronides danae. **3.** Skull of adult, dorsal view; standard length 488 mm. (x 2.2). **4.** Same, teeth of upper jaw and vomer, ventral view. (x 2.2). **5.** Same, bones of head, pectoral girdle and anterior part of vertebral column, lateral view. (x 2.2).



Text-figure 6.

Platuronides danae. Hyoid and branchial apparatus of adult, standard length 488 mm. (x 3.9).

2. The ethmo-vomer, correlated with the lighter burden of the teeth, is more slender.
3. The maxillary in this species and, according to Parr (1932, p. 6) in *P. ophiocephalus,* extends almost to the tip of the ethmo-vomer, instead of ending far behind it, as in *Platuronides acutus* and in both species of *Serrivomer* studied.
4. The articular and interopercular are both larger than in *Serrivomer.*
5. The pharyngeal teeth are less highly developed.

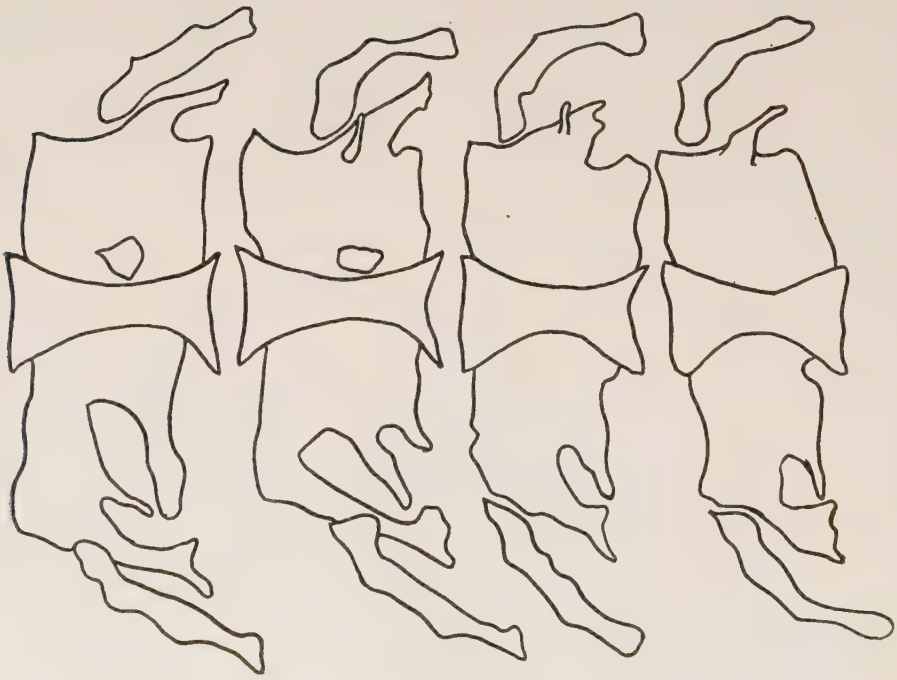
Unfortunately, the bones of the caudal fin fell to pieces in the process of clearing and staining, so that a study of them was impossible. However, a series of typical vertebrae near the tail (about the 161st to 164th), is shown in Text-fig. 7. The strength of the neural and haemal elements, for the purpose of the powerful posterior portions of the dorsal and anal fins, is apparent when compared with the slightness of corresponding elements in *Serrivomer* (*Zoologica,* Vol. XX, No. 3, Fig. 33).

Coelomic Organs: (Text-fig. 8). The coelomic organs of the 488 mm. specimen of *P. danae* differ from those of *Serrivomer* in that the liver is more extensive and the kidneys and gonads both extend farther posteriorly. While all of the specimens of *Serrivomer* examined were females, the adult *Platuronides danae* was a male, not in breeding condition.

Development.

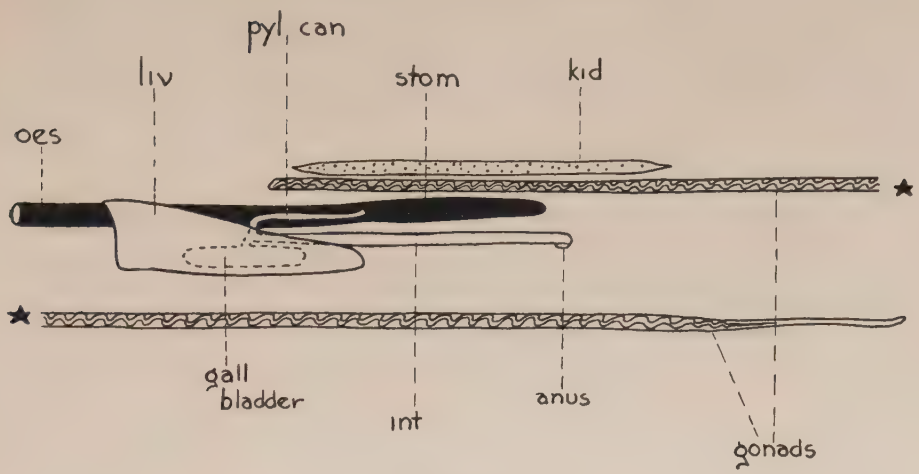
(Text-fig. 2).

The collection contains six moderately advanced larvae, measuring between 31 and 61 mm. in length in addition to the single adult, 488 mm.



Text-figure 7.

Platuronides danae. Vertebrae and fin supports of adult, standard length 488 mm., near base of tail (vertebrae about 161st to 164th). (x 78).



Text-figure 8.

Platuronides danae. Viscera of adult, standard length 488 mm.; oes: oesophagus; stom: stomach; liv: liver; int: intestine; kid: kidney. The kidneys were damaged so that it was impossible to trace the course of their ducts. (x .5).

long, described above. The characteristics of the larvae are described on pp. 332 and 333.

Ecology

Seasonal and Vertical Distribution: The present material is insufficient for the drawing of any conclusions. It may be remarked, however, that five of the six larvae, measuring between 31 and 38 mm. in length, were taken during July of three different years; the sixth larva, measuring 61 mm., was caught in August and the 488 mm. adult male in May. The larvae occurred between 50 and 900 fathoms, the adult male at 1,000 fathoms.

Abundance: *Platuronides danae* is one of the rarest of all Bermuda deep-sea fishes.

Study Material.

The following list gives the catalogue number, depth in fathoms, date of capture, length and growth stage of each specimen of *Platuronides danae* taken by the Bermuda Oceanographic Expeditions. All were caught in the cylinder of water off the Bermuda coast described in *Zoologica,* Vol. XVI, No. 1, p. 5.

No. 10,292; Net 145; 1,000 F.; May 31, 1929; 488 mm.; Adult.
No. 11,866; Net 329; 800 F.; July 27, 1929; 37 mm.; Larva.
No. 11,867; Net 330; 900 F.; July 27, 1929; 36, 38 mm.; Larvae.
No. 12,967; Net 412; 800 F.; Sept. 3, 1929; 61 mm.; Larva.
No. 17,039; Net 801; 900 F.; July 15, 1930; 33 mm.; Larva.
No. 21,325a; Net 1075; 50 F.; July 11, 1931; 31 mm.; Larva.

References.

Platuronides danae:
Roule & Bertin, 1924. p. 61. (Preliminary description of type specimen).

Roule & Bertin, 1929, p. 48; pl. I, fig. 3; text-figs. 32-34. (1 specimen; 486 mm.; 25° 35′ N. Lat., 74° 45′ W. Long.; about 600 metres—1,000 metres of wire; *type specimen*).

Parr, 1932, p. 5. (Key to the species of *Platuronides*).

Platuronides acutus Parr 1932.

Specimens Taken by the Bermuda Oceanographic Expeditions.

22 specimens; April to September, 1929 to 1931; 100 to 1,000 fathoms; from a cylinder of water 8 miles in diameter (5 to 13 miles south of Nonsuch Island, Bermuda), the center of which is at 32° 12′ N. Lat., 64° 36′ W. Long.; standard lengths from 18 to 178 mm.

Specimen Previously Recorded.

A single specimen; at about 850 fathoms? (10,000 feet of wire); off Bermuda; length 220 mm.

Description of Largest Known Specimens.

(Text-fig. 9F).

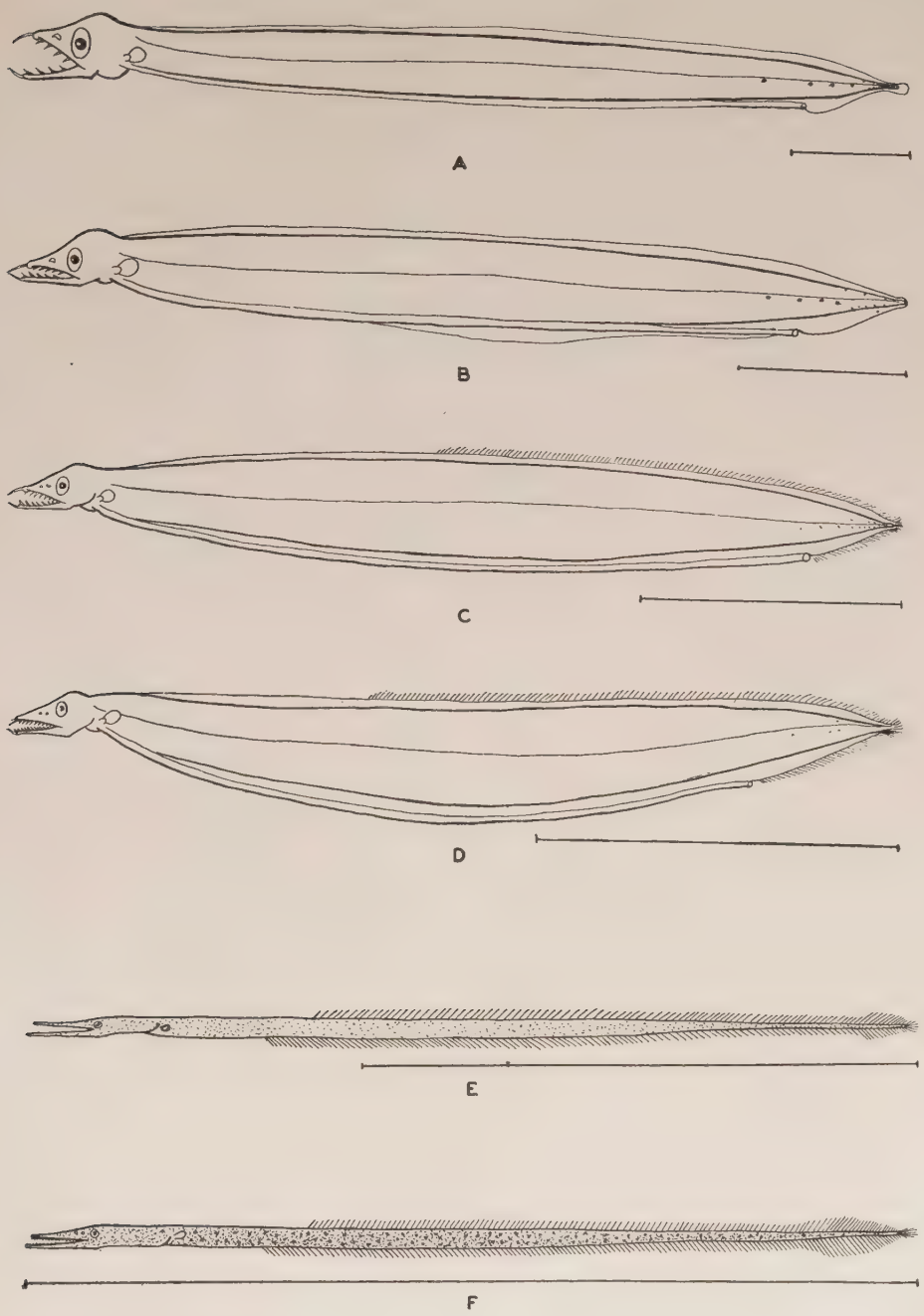
(Based upon the description of the type, and upon two transitional adolescents of the present collections, measuring 133 and 178 mm. in length, respectively).

Color: Dark brownish black, with no trace of the silvery skin characteristic of *Serrivomer*. Skin dotted with black chromatophores.

Proportions: Maximum depth (immediately behind head) in length 40 to 50 (2 to 2.5 per cent.); head in length 6.1 to 6.5 (15.5 to 16.5 per cent.); eye (horizontal) in head 16 to 24 (0.7 to 0.9 per cent. of length); snout in head 2.7 to 2.8 (5.5 to 6 per cent. of length); lower jaw slightly longer than upper; vomer projecting about one-third length of snout beyond tip of maxillary; intersphenotic width 40 to 60 per cent. greater than interorbital width; interorbital width in length 77 to 102 (.98 to 1.3 per cent.); intersphenotic width 56 to 62 in length (1.6 to 1.8 per cent.); snout to dorsal origin in length 3 to 3.2 (31.5 to 32 per cent.); snout to anal origin in length 3.7 to 4 (25 to 27 per cent.).

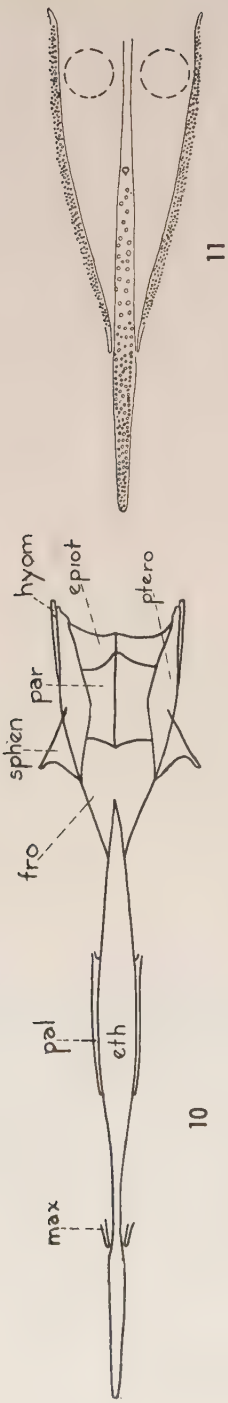
Nostrils: Non-tubular.

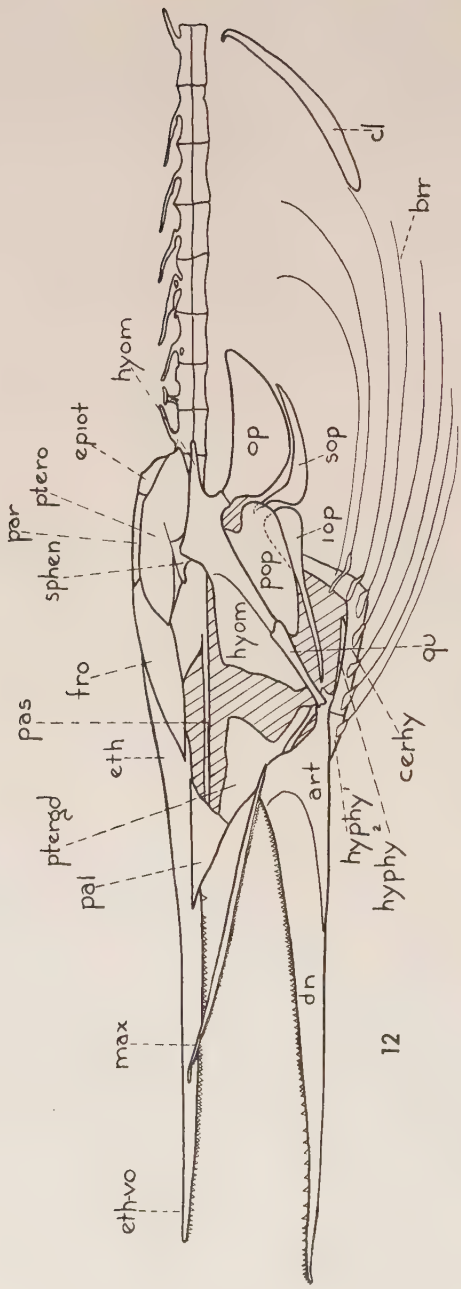
Teeth: (Text-figs. 10-12). The maxillary and mandibular teeth are numerous, small and pointed and arranged in from three to six irregular rows; in the mandible they are slightly larger than in the maxillary. In the 220 mm. type specimen, Parr (1932, pp. 9-10) describes the vomerine teeth thus: "Anterior portion (head) of vomer with a band of numerous small, irregularly scattered, conical teeth, about 5 or 6 wide at the broadest part, with the teeth nearest to the median somewhat larger than the others. Posteriorly these teeth become gradually larger and more compressed, and continue as a double row of alternating, compressed and somewhat decurved teeth on the shaft of the vomer. There are about 40-60 teeth in a longitudinal count on the anterior part of the vomer, depending upon the manner in which they are counted, and the posterior row on the shaft has about 8-9 teeth on each side of the median. While the latter are larger than the conical teeth on the anterior portion, they are not so large, nor quite so broad and compressed, as those of *P. ophiocephalus* or of *Serrivomer*, and their free portions do not overlap in the lateral view to nearly the same extent as in the latter forms. The anterior conical dentition also extends much farther backward in *P. acutus*, so that the posterior compressed series



Text-figure 9.

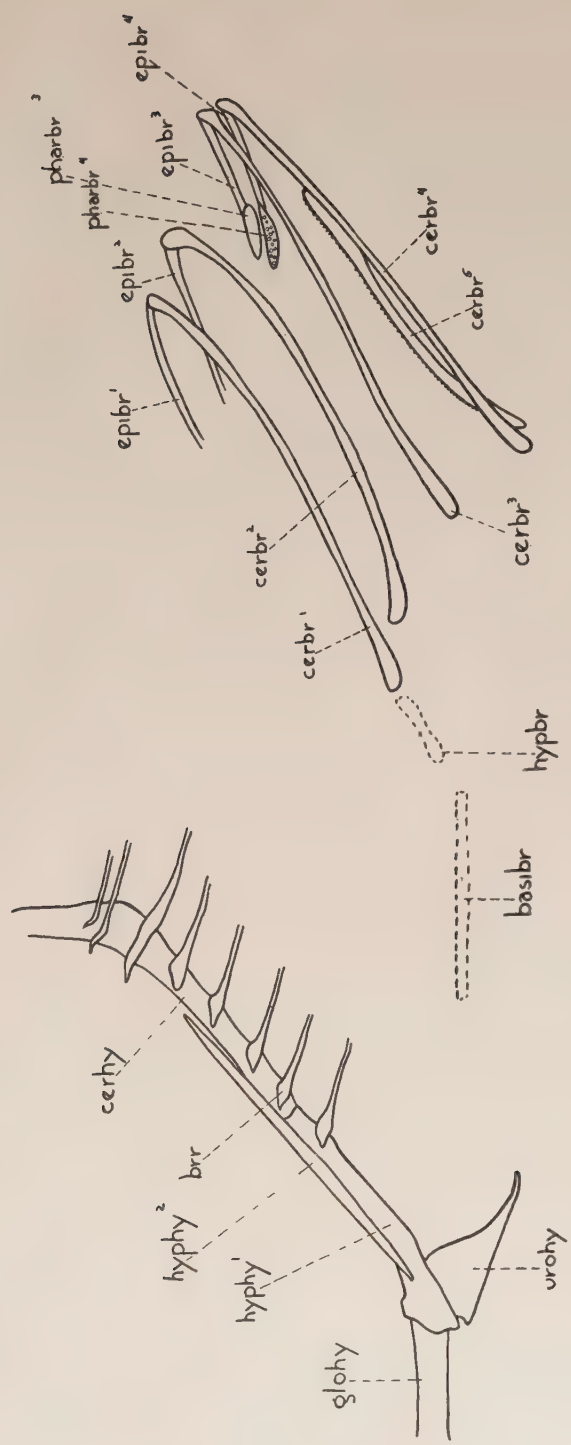
Platuronides acutus. **A** to **D**, incl., larvae, 18, 26, 40 and 56 mm., respectively; **E**, adolescent, 92 mm.; **F**, transitional adolescent, 133 mm.





Text-figures 10-12.

Platuronides acutus. **10.** Skull of transitional adolescent, dorsal view; standard length 133 mm. (x 6.8). **11.** Same, teeth of upper jaw and vomer, ventral view. (x 6.8). **12.** Same, bones of head, pectoral girdle and anterior part of vertebral column, lateral view. (x 6.8).



Text-figure 13.

Platuronides acutus. Hyoid and branchial apparatus of transitional adolescent, standard length 133 mm. (x 14.6).

is relatively much shorter than in *P. ophiocephalus* . . . although the vomerine dentition reaches almost to the eyes in both." In the most advanced specimens of the present collection, all smaller than the type, the teeth of the posterior part of the vomer differ less from those of the anterior part, are scarcely larger, only slightly flattened, well separated and do not yet form a regular series (see Text-fig. 11). Similar developmental stages were found in *Serrivomer*. Also, relatively more of the vomer protrudes than in the type—another growth character which is common to both genera.

Fins: Pectoral rays 6 to 8, equal in length to vertical diameter of eye, inserted at upper angle of branchial cleft; dorsal rays about 185 to 190; anal rays about 180 to 185.

Osteology: (Text-figs. 10-14). The small size of the specimen studied (133 mm.) makes difficult comparison with the large specimens of *Platuronides danae* and of *Serrivomer* which have been studied, since all of these measure around 500 mm. in length. The following points, however, are evident: The differences given on p. 335 between *P. danae* and *Serrivomer* are true of *P. acutus* also, except that the maxillary extends farther anteriorly. The relatively greater extent of parietals and frontals, and the lesser spread of such elements as the hyomandibular and the dorsal laminae of the sphenotic are obviously due to the specimen's immaturity (cf. *Serrivomer, Zoologica,* Vol. XX, No. 3, Figs. 26-31 and 37-40).

Since the size of the specimen is even more important in a study of the vertebral column and caudal fin than of the osteology of the head, no comparison at all can be made between these regions in *P. acutus* and in *P. danae* and *Serrivomer*.

Development.

(Text-fig. 9).

Material: The collection consists of larvae, adolescents and transitional adolescents, as follows:

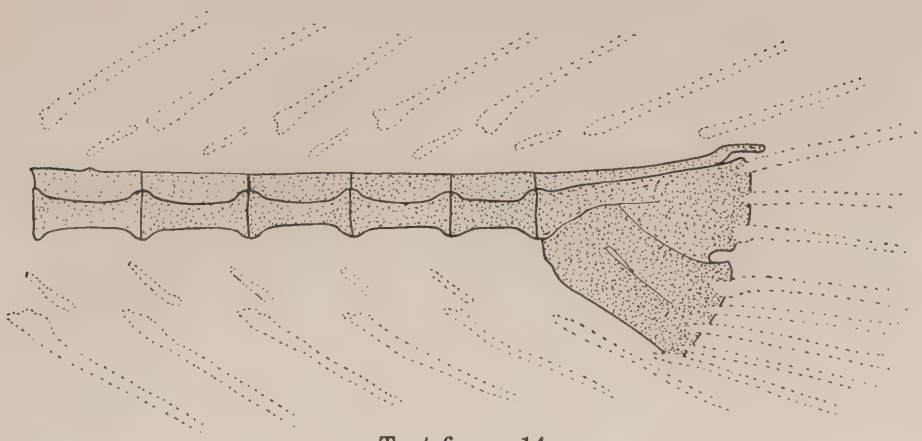
Larvae, 18 to 62 mm.: 14 specimens.
Adolescents, 90, 92 mm.: 2 specimens.
Transitional Adolescents, 70 to 178 mm.: 6 specimens.
Total: 22 specimens.

Discussion: The characteristics of the larvae are described on pp. 332 and 333. Save for the difference in the position of the anus (at the 102nd to the 125th myomere, not between the 89th to 97th), the Key to the Growth Stages under the discussion of *Serrivomer* (*Zoologica,* Vol. XX, p. 80), serves very well for *Platuronides*. The shortness (70 mm.) of one of the present transitional adolescents is noteworthy: it may indicate a shrinkage of 20 mm. during the adolescent stage, or simply an unusually short elver. Evidences of the characteristic pseudo-caudal are not apparent until adolescence.

Ecology.

Seasonal and Vertical Distribution: More than two-thirds of the specimens were taken in June and July, although the material is not sufficient to serve as a basis for conclusions. The larvae occurred between 100 and 1,000 fathoms, adolescents at 600 and 700 fathoms and transitional adolescents between 500 and 1,000 fathoms.

Abundance: *Platuronides acutus* is rare among the deep-sea fishes of Bermuda.



Text-figure 14.
Platuronides acutus. Posterior part of vertebral column and base of caudal fin in transitional adolescent, standard length 133 mm. (x 70).

Study Material.

The following list gives the catalogue number, depth in fathoms, date of capture, length and growth stage of each specimen of *Platuronides acutus* taken by the Bermuda Oceanographic Expeditions. All were caught in the cylinder of water off the Bermuda coast described in *Zoologica*, Vol. XVI, No. 1, p. 5. "Trans. Adol." stands for "Transitional Adolescent."

No. 9,625a; Net 41; 600 F.; April 25, 1929; 92 mm.; Adolescent.
No. 9,879; Net 89; 600 F.; May 10, 1929; 120 mm.; Trans. Adol.
No. 10,257; Net 140; 500 F.; May 31, 1929; 123 mm.; Trans. Adol.
No. 10,272; Net 144; 900 F.; May 31, 1929; 70 mm. Trans. Adol.
No. 11,152; Net 239; 600 F.; June 29, 1929; 30 mm.; Larva.
No. 11,281; Net 256; 700 F.; July 7, 1929; 92 mm.; Adolescent.
No. 11,400; Net 277; 1,000 F.; July 9, 1929; 178 mm.; Trans. Adol.
No. 11,459; Net 283; 1,000 F.; July 10, 1929; 42 mm.; Larva.
No. 11,563; Net 302; 1,000 F.; July 13, 1929; 38 mm.; Larva.
No. 12,589; Net 304; 500 F.; July 16, 1929; 62 mm.; Larva.
No. 11,647; Net 307; 800 F.; July 16, 1929; 29 mm.; Larva.
No. 11,698; Net 310; 600 F.; July 22, 1929; 40 mm.; Larva.
No. 11,745; Net 315; 500 F.; July 23, 1929; 133 mm.; Trans. Adol.
No. 12,114; Net 356; 700 F.; Aug. 8, 1929; 106 mm.; Trans. Adol.
No. 15,659; Net 658; 700 F.; June 2, 1930; 20 mm.; Larva.
No. 16,211; Net 730; 1,000 F.; June 26, 1930; 18 mm.; Larva.
No. 21,018a; Net 1043; 300 F.; June 26, 1931; 26 mm.; Larva.
No. 21,148; Net 1057; 100 F.; July 7, 1931; 29 mm.; Larva.
No. 21,156; Net 1059; 100 F.; July 8, 1931; 30 mm.; Larva.
No. 21,320; Net 1078; 300 F.; July 11, 1931; 33 mm.; Larva.
No. 23,038a; Net 1243; 700 F.; Aug. 31, 1931; 26 mm.; Larva.
No. 23,255; Net 1280; 900 F.; Sept. 9, 1931; 56 mm.; Larva.

References.

Platuronides acutus:

Parr, 1932, p. 8; text-figs. 4, 5. (1 specimen; 220 mm.; off Bermuda, 32° 24′ 15″ N. Lat., 64° 29′ W. Long.; 10,000-foot wire, *type specimen*).

Family SERRIVOMERIDAE.

Characteristics: Naked deep-sea eels with the body slender and the jaws moderately attenuated; snout less than half length of head; maxillary and mandibular teeth small, erect, pointed, set in one or more rows; vomerine teeth larger, erect, compressed or conical, in one or two rows; two pairs of large nostrils and three pairs of tiny ones, all set close in front of eye; anterior nostril tubular or non-tubular; nuchal constriction absent; gill openings present, confluent; anus in advance of middle of length; pectoral fins vestigial; dorsal fin rays short, feeble; anal rays longer; both dorsal and anal confluent with caudal, sometimes (in *Platuronides*) lengthened and strengthened posteriorly to form a spatulate pseudo-caudal; lateral line pores present or absent, never large or conspicuous; caudal filament absent.

Skeleton[4] moderately well developed; frontals and parietals paired, united by suture; supraoccipital absent; wing-like posterior processes on epiotics, pterotics and hyomandibulars; no conspicuous bony channels for sensory canal system; palato-pterygoid large and laminar; hyomandibular and quadrate forming with the mandible an angle of about 120°; mandible equal to or slightly longer than ethmo-vomer; ethmo-vomer projecting less than half the length of the maxillary beyond anterior tip of latter bone; hyoid, branchial and opercular apparatus complete, moderately well ossified; branchiostegal rays six to 12; supracleithrum absent; cleithrum and coracoids reduced; radials absent; vertical fins feebly supported, vertebrae moderately numerous, 143 to 171.

Coelom relatively small; intestine straight; a single caecal pouch; stomach black, a blind sac; liver small; kidney ending slightly behind anus; gonads dorsal, extending far behind all other organs.

Affinities: In most of their characteristics, the Serrivomeridae show distinctly less specialization than the Nemichthyidae: their jaws are shorter, bodies less attentuated, anus more posteriorly placed, palato-pterygoids well developed, opercular, hyoid and branchial apparatus complete, and vertebrae less numerous. However, in their teeth and vestigial pectoral fins they are even more highly specialized than the Nemichthyidae; it is interesting to note that in adolescent and young transitional adolescent serrivomerids the teeth, in numbers, shortness and banded arrangement, resemble those of older nemichthyids.

On the other hand, serrivomerids appear less advanced in every way than the cyemids. Their relation to *Avocettinops* Roule and Bertin (1924) and *Gavialiceps* Alcock (1889), as well as to the nearest non-nemichthyidiform groups, should prove to be of the greatest interest when these questions can be investigated through osteological studies.

Taxonomic Discussion: Five genera have been described which properly belong in this family: *Serrivomer* Gill and Ryder (1883), *Spinivomer* Gill and Ryder (1883), *Gavialiceps* Alcock (1889), *Platuronides* Roule and Bertin (1924) and *Paraserrivomer* Roule and Angel (1931). A sixth genus, *Stemonidium* Gilbert (1905), as Trewavas has pointed out (1932, p. 652), has the external characters of the serrivomerids, but the teeth of a typical nemichthyid.

The unique specimen of *Spinivomer*, a poorly described Atlantic form measuring only 147 mm. in length, has been temporarily mislaid at the United States National Museum. From the type description—which records it as bright silvery in color and as not having typical, compressed, vomerine teeth—it seems almost certain that this specimen will prove to be a young *Serrivomer* for the following reasons: first, at a similar length specimens of the latter genus are distinctly silvery, while corresponding specimens of

[4] From studies of *Serrivomer* and *Platuronides*.

Platuronides are already dusky; second, the vomerine teeth of *Serrivomer*, as pointed out in a previous paper (Beebe and Crane, 1936, p. 85), do not attain their characteristic form and arrangement until the fish has reached a length of at least 150 mm.

Gavialiceps, a poorly known genus from the Indian Ocean, is distinguished from *Serrivomer* chiefly by the lack of pectoral fins. As Roule and Angel (1931, pp. 2-3; 1933, p. 72), have remarked, it is likely that the fins have been destroyed or overlooked because of their delicacy, and that the genus is actually synonymous with *Serrivomer* or *Paraserrivomer*. We have already (Beebe and Crane, 1936, p. 62) recorded the fact that the Atlantic specimens referred to *Gavialiceps microps* Alcock by Borodin (1929, p. 74) are typical examples of *Serrivomer beanii*.

Paraserrivomer hasta (Zugmayer), 1911, first described as an Atlantic species of *Gavialiceps*, is distinguished from *Serrivomer* chiefly by spatulate enlargements on the tips of the jaws. These swellings are very similar to those found in the Nemichthyidae, although the genus is typically serrivomerid in every other respect.

The two remaining genera, *Serrivomer* and *Platuronides*, both represented in the Bermuda collection, have already been discussed at length in the present paper and in *Zoologica*, Vol. XX, No. 3. Parr's key to these two genera (1932, p. 5) has proved satisfactory in distinguishing larger specimens. Means of identifying the larvae and elvers are set forth in the present paper on pp. 331-333.

Note on Synonomy of *Serrivomer beanii*.

The 173 mm. Atlantic specimen referred by Borodin (1931, p. 73 and pl. V, fig. 3) to *Nemichthys* sp. has been examined by us at the Museum of Comparative Zoology and found to be a transitional adolescent example of *Serrivomer beanii*. The *Saccopharnyx*-like pouch formed by the expanded position of the hyoid apparatus can be observed in a number of *Serrivomer* in the Bermuda collection. Although the specimen is in poor condition, the character of the vomerine teeth and the anteriorly elongate branchiostegal rays leave no doubt as to its identity. This taxonomic correction should be added to the synonomy of *S. beanii* as given in *Zoologica*, Vol. XX, No. 3, pp. 61-63. (The present museum label of the specimen (M. C. Z. No. 32,299) is inscribed "*Nemichthys saccopharingoides* n. sp?").

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27.

Deep-sea Fishes of the Bermuda Oceanographic Expeditions. Family Nemichthyidae[1].

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Department of Tropical Research, New York Zoological Society.

(Text-figures 1-22).

INTRODUCTION.

For detailed data in regard to nets, locality, dates, etc., concerning the capture of the deep-sea eels treated in this monograph, refer to *Zoologica*, Vol. XIII, Nos. 1, 2 and 3, and Vol. XX, No. 1, pp. 1-2. For physical data, methods of measurement and definitions of growth stages, see *Zoologica*, Vol. XVI, No. 1.

The drawings are the work of George Swanson.

We wish Dr. L. P. Schultz and Dr. Thomas M. Barbour to accept our thanks for their cooperation in enabling us to examine specimens deposited in the United States National Museum and in the Museum of Comparative Zoology.

IMPORTANT POINTS IN THE FOLLOWING STUDY OF THE NEMICHTHYIDAE.

Taxonomy: 1. Contrary to recent opinions that the genus *Nemichthys* is mono-specific, we conclude that it contains at least two species, *Nemichthys scolopaceus* Richardson of cosmopolitan distribution, and *Nemichthys fronto* Garman from the eastern Pacific.

2. There are two valid Atlantic species of *Avocettina*, *A. infans* Günther of presumably cosmopolitan distribution and *A. exophthalma* Parr from the West Indies; in addition, at least one undescribed species is probably included among the examples of this genus already recorded from the Atlantic. The third known Atlantic species, *A. elongata* (Gill and Ryder), is synonymous with *A. infans*. *A. bowersii* Garman, from the eastern Pacific, is valid, as is probably *A. gilli* (Bean) from Alaska. The final decision concerning the latter species, however, must await a redefinition of *A. infans*.

3. The development of *Nemichthys* is traced through a consecutive series of stages, proving that the form "Leptocephalus B," considered by Roule and Bertin (1929) to be a giant albino or variable larva of *Nemichthys scolopaceus*, belongs to a different species and probably a different genus; the same is true of some of the older larvae described in their report.

4. The specimens recorded by Borodin (1931, pp. 73-74) as *Tilurella Nemichthydis infantis*, *Nemichthys infans* and *Serrivomer sector* are all

[1] Contribution No. 547, Department of Tropical Research, New York Zoological Society. Contribution, Bermuda Biological Station for Research, Inc.

post-larval and adolescent specimens of *Nemichthys scolopaceus*. *Nemichthys* sp., described in the same place, is a transitional adolescent *S. beanii*.

Structure: 1. The teeth of *Nemichthys* are set in curving bands, rather than in the quincunx formation typical of *Avocettina* and *Labichthys*.

2. The skeleton of *Labichthys* is less specialized than those of the other genera.

3. Coelomic organs are unpigmented in *Avocettina*.

4. Although *Labichthys* and *Avocettina* are more closely related to each other than to *Nemichthys, Nematoprora* and *Cercomitus*, yet these genera have far more osteological similarities than differences when compared with their near neighbors, the Serrivomeridae and Cyemidae. Hence they are included in a single family, the Nemichthyidae.

Ecology: 1. Next to *Serrivomer beanii* and *Eurypharynx pelecanoides*, *Nemichthys scolopaceus* is the most common deep-sea eel found in our Bermuda trawling area, 45 specimens having been taken in the nets. *Labichthys*, on the other hand, is represented by only three specimens and *Avocettina* by one.

2. Young, six-inch nemichthyid eels (provisionally identified as *Labichthys*) were recognized from the bathysphere at a depth of only 75 fathoms, far above the level at which specimens of this size have been taken in the nets (500 to 1,000 fathoms).

Family Nemichthyidae.

Characteristics: Naked deep-sea eels with the body extremely slender and jaws excessively attenuated; snout much more than half length of head; teeth small with backwardly directed, curving tips, numerous, set in curving bands or quincunxial rows; two pairs of large nostrils, the anterior with short tube, close in front of eye; nuchal constriction present; gill openings well developed, convergent forward; anus far in advance of middle of length; pectorals and vertical fins well developed; fin membranes thin, not enveloping rays; lateral line pores present or absent; caudal filament present or absent.

Skeleton moderately well developed; frontals united anteriorly; parietals separate or united; supraoccipital present or absent; pterotic large with sensory canal tube extending forward to overlap frontals; palatine absent; pterygoid much reduced or absent; hyomandibular and quadrate forming with the mandible an angle of slightly more than 90 degrees; anterior end of frontal intercalated with the divided posterior end of ethmo-vomer, the two prongs of which join or almost join above the frontal; mandible shorter than ethmo-vomer; maxillary very short, articulating with the excessively elongate ethmo-vomer near its base; opercular apparatus reduced and little ossified, the opercle alone being constantly present; preopercle always absent; hyoid and branchial apparati both reduced and feebly ossified, the pharygobranchials being strongest; branchiostegal rays 7 to 10; supracleithrum absent; cleithrum, coracoids and radials feebly or moderately ossified; vertical fins feebly supported, not well ossified; vertebrae numerous, increasing with age, 170 to more than 500.

Coelom relatively small; intestine curved forward on its own length; a single small caecum; stomach a blind sac; liver small, elongate; kidney extremely elongate; gonads dorsal, extending farther posteriorly than all other organs except kidney.

Affinities: As already pointed out in our discussion of the Serrivomeridae (*Zoologica*, Vol. XXII, No. 26, p. 346), the nemichthyids are in most respects more highly specialized than the serrivomerids, as is shown by

their extremely elongated jaws, attenuated bodies, more anteriorly placed anus, reduced or vestigial palato-pterygoid, opercular, hyoid and branchial apparatus, and more numerous vertebrae. Their teeth and comparatively strong pectorals, however, are characters less highly differentiated than in the serrivomerids.

In the Cyemidae the opercular and branchial apparatus is even more reduced than in the nemichthyids, although the jaws are similar. The excessive reduction of its vertebrae in a group noted for a high vertebral count leads to interesting speculations on ancestral forms.

Because of the close osteological relationships of *Nemichthys* and *Nematoprora* with *Avocettina* and *Labichthys* these four genera are at present, with *Cercomitus*, considered to form a single family (see below).

Taxonomic Discussion: Five genera have been described, *Nemichthys* Richardson (1848), *Labichthys* Gill and Ryder (1883), *Avocettina* Jordan and Davis (1888), *Nematoprora* Gilbert (1905) and *Cercomitus* Weber (1913). *Nemichthys* and *Avocettina* are of cosmopolitan distribution, *Labichthys* is known only from the Atlantic, and *Nematoprora* and *Cercomitus* have been taken only in the Pacific, although evidence is accumulating to show that one or both of these genera also occur in the Atlantic (see p. 361). The first three genera are all represented in the collections taken on the Bermuda Oceanographic Expeditions.

Key to the Genera.

A. Lateral line with pores.
  B. Three rows of tiny pores; caudal filament present; vertebrae not fewer than 300, usually many more.....*Nemichthys*
  BB. A single row of large pores; caudal filament absent; vertebrae not more than 200.
    C. Anal origin scarcely behind level of pectoral base.....*Labichthys*
    CC. Anal origin well behind level of pectoral base, the postorbital distance being contained more than one and three-quarters times the distance between pectoral base and anal origin. .....*Avocettina*

AA. Lateral line without pores.
  D. Gill slits narrow; backwardly directed points on teeth well developed, conspicuous.....*Cercomitus*
  DD. Gill slits wide, points on teeth small, inconspicuous.....*Nematoprora*

Genus **Nemichthys** Richardson, 1848.

Generic Characters: Nemichthyids with three rows of minute pores in the lateral line; caudal filament present; ethmo-vomerine teeth in eight longitudinal rows set in curving, transverse bands; anus and anal origin scarcely behind level of pectoral base; dorsal origin on occiput, in advance of level of pectoral base; dorsal rays in middle third of body short, spinous.

Parietals separated by suture; supraoccipital absent; pterygoid absent; mandible slightly shorter than ethmo-vomer; preopercle, subopercle and interopercle absent; glossohyal, basihyal and hypohyals absent; ceratohyal feebly ossified with eight strongly curved branchiostegals; branchial apparatus completely cartilaginous except for faintly ossified pharyngobranchials; basibranchials apparently absent; coracoid and four radials ankylosed, feebly ossified; cleithrum at level of fifth vertebra; vertebrae 300 (in young specimens) to 660.

Leptocephalus characterized by an elongate body, long snout (but not of characteristic *Nemichthys* attenuation), posteriorly placed anus, many myomeres and characteristic pigmentation (see pp. 357 ff.)

Discussion: In their monograph on the nemichthyid eels published in 1929, Roule and Bertin decided that, in spite of the tremendous differences in proportions and differences of range, all of the recorded specimens of *Nemichthys* belonged to a single species, *Nemichthys scolopaceus*, first described by Richardson in 1848. The extensive *Dana* collections, they reasoned, provided ample material for the study of variation, and they found, through numerous measurements, that the variations of each character gave a normal curve with a single, median node, and that specimens of various types were not confined to one geographical area: for example, specimens with very large eyes were taken in the same region with small- and medium-eyed examples.

Our careful examination of their evidence can find no flaw in their reasoning: the liability of both the jaws and caudal filament to injury leaves very few characters which can be accurately measured, the best of these being the relation of the diameter of the eye to the postorbital length of the head. Nevertheless, especially in the light of the presence of at least two forms of *Nemichthys*-like larvae (see pp. 357 ff.), it seems inevitable that two or more species are included in the *Dana* collection, and that at least one or two of the other species of *Nemichthys* synonymized by Roule and Bertin with *N. scolopaceus* will, in the light of future material, prove to be valid.

It may be stated here that *Nemichthys fronto*[2] Garman, 1899, from the west coast of central America appears to be perfectly valid: every single one of the *Dana* specimens from the Gulf of Panama (Roule and Bertin, 1929, Tables III and IV, pp. 14-15 and 17-18) have the small eyes (or large postorbital distances) characteristic of that species, the diameter being contained in the postorbital length of the head 3.6 to 5.3 times. Small-eyed specimens were, however, taken in the Atlantic as well.

The extremes of proportions, which include those of other authors as well within the *Dana* material, are as follows: Maximum height of trunk in length 39 to 200; head in length 9 to 21 times; caudal filament 2.3 to 6.3 times in length; length of snout in head 1.3 to 1.8; eye diameter in head length 7.4 to 18.2; eye diameter in snout length 4.5 to 13; diameter of eye in postorbital length 1.4 to 5.3; pectoral length in postorbital length 0.5 to 3.5.

It will be seen that all of these proportions far exceed normal ranges of specific variation. At present, nevertheless, we can only agree with Roule and Bertin—except that we maintain the validity of *N. fronto*—and refer the known specimens of the genus to *N. scolopaceus*.

The following species referable to *Nemichthys* have been described: *Nemichthys scolopaceus* Richardson (1848), *Leptorhynchus leuchtenbergi* Lowe (1852), *Belonopsis leuchtenbergi* Brandt (1854), *Nemichthys acanthonotus* Alcock (1892), *Nemichthys fronto* Garman (1899), *Nemichthys mediterraneus* Ariola (1904), *Leptocephalus canaricus* Lea (1913), *Leptocephalus andreae* Schmidt (1912) and *Tilurella gaussiana* Pappenheim (1914). *Nemichthys avocetta* Jordan and Gilbert (1880), since it apparently lacks a lateral line, probably belongs to another genus.

In addition to type descriptions, the chief references to this relatively well known genus of deep-sea eels are the following. *Nemichthys scolopaceus*: Günther (1887), Vaillant (1888), Goode and Bean (1895), Jordan

[2] We have examined the type specimen, deposited in the Museum of Comparative Zoology, and found the original description to be accurate.

and Evermann (1896), Brauer (1906), Roule and Bertin (1929), Norman (1930) and Borodin (1931)[3].

Nemichthys has previously been taken from the western Atlantic by the *Blake* (Goode and Bean, 1895), by fishermen (Mowbray, 1922), by the *Dana* (Roule and Bertin, 1929) and by the *Atlantis* (Borodin, 1931).

In the following pages a description is given of the largest (transitional adolescent) Bermuda specimens as well as of a series of growth stages taken in the same locality.

Nemichthys scolopaceus Richardson, 1848.

Specimens Taken by the Bermuda Oceanographic Expeditions.

45 specimens; April to September, 1929 to 1931; 50 to 1,000 fathoms; from a cylinder of water 8 miles in diameter (5 to 13 miles south of Nonsuch Island, Bermuda), the center of which is at 32° 12′ N. Lat., 64° 36′ W. Long.; standard lengths from 40 to 357 mm.

Specimens Previously Recorded.

About 110 adult and almost adult specimens in addition to about 675 larvae and young; surface to 3,281 fathoms; North Atlantic, Mediterranean, Indian Ocean and East Indies from the equator to about 40° N.; lengths from 9 to 1,445 mm.

Description of Transitional Adolescent.

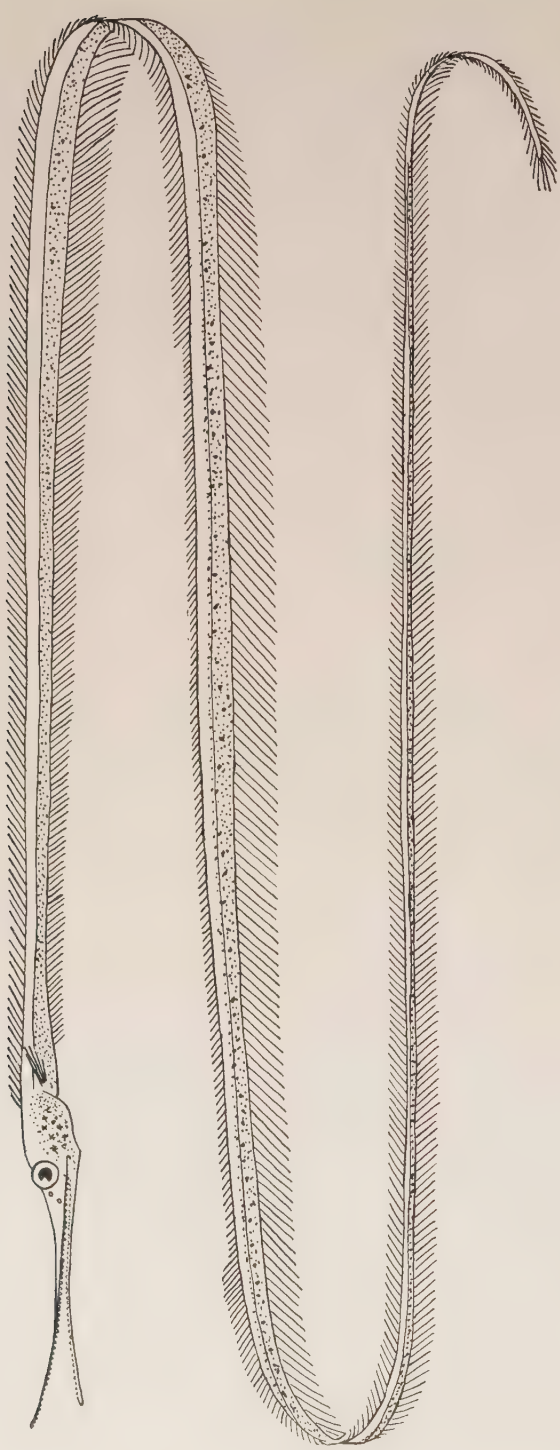
(Text-figs. 1, 2, 3C, 4G, 5G).

The following measurements and observations are taken from the three largest specimens in the Bermuda collection. All three have snout tips and caudal filaments complete and measure, respectively, 342, 342 and 357 mm. without caudal fin. The small amount of variation in the proportions, compared with the large amount in the series described by Roule and Bertin (1929) is notable. It will also be seen that the proportions do not differ markedly from those of the type, when allowance has been made both for the difference in age and for the possible damage to the snout tip in the type; the most reliable proportion, that of the eye in the postorbital distance, is seen to be very close in the two cases: 2.2 in the type, 2.4 to 2.9 in the present specimens, when these figures are compared with the great range of 1.4 to 5.3 in the series described by Roule and Bertin.

Color: (Fresh specimens). Pale tan to light brown (most advanced specimen), the ventral two-thirds of the body marked by dendritic chromatophores which are largest and densest on the abdomen. There are a few similar pigment spots on the proximal parts of the jaws and on the crown of the head, while the caudal filament is very sparsely pigmented, and that only on the ventral surface.

Proportions: Maximum depth (in advance of middle of body) in length 118 to 132 (.76 % to .85 %); depth of caudal filament at caudal base in eye diameted 6.9 to 8.1 (.0008 % to .0009 % of length); head in length 12.3 to 12.8 (7.8 % to 8.1 %); eye in head 12.2 to 13.2, in snout 8.4 to 9.3, in postorbital 2.4 to 2.9 (.62 % to .64 % of length); snout in head 1.4 to

[3] Specimens recorded (1931, pp. 73-74) as *Nemichthys infans, Tilurella Nemichthydis infantis* and *Serrivomer sector* examined by us in Museum of Comparative Zoology and found to be postlarval and adolescent *Nemichthys scolopaceus*, identifiable by their myomeral counts, pigmentation and rudimentary, but distinct, caudal filaments. The specimen described as *Nemichthys* sp. is a transitional adolescent *Serrivomer beanii*, identifiable by means of the teeth and the anterior prolongation of the branchiostegal rays.



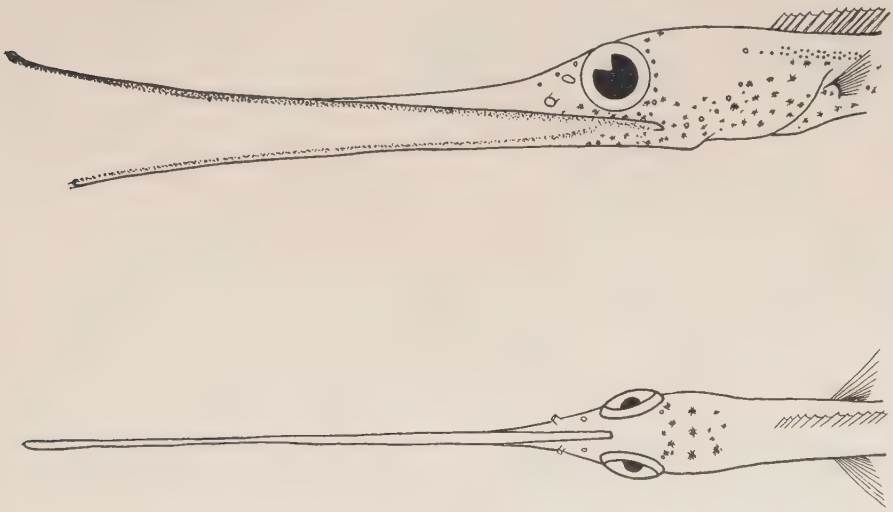
Text-figure 1.
Nemichthys scolopaceus. Standard length 342 mm. The complete numbers of fin rays are not indicated.

1.45 (5.4 % to 5.7 % of length); postorbital in head 4.6 to 5.2, in snout 3.2 to 3.7, (1.5 % to 1.8 % of length); interorbital in head 26.4 to 27, in eye 2 to 2.2, (.31 % to .34 % of length); maxillary extending slightly beyond posterior margin of orbit; tip of snout to tip of mandible in length of snout 15.4 to 17.1 (.33 % to .34 % of length; pectoral base to anal origin in postorbital length of head 1.6 to 1.8, (.94 % to .96 % of length); pectoral length in postorbital length 1.9 to 2.1; caudal filament in length 3.1 to 3.3 (30.4 % to 33 %).

Teeth: (Text-figs. 3C, 6, 7, 8). The maxillary holds a maximum of four rows of teeth irregularly arranged. On the ethmo-vomer there are, in the broadest portion, eight longitudinal rows set, not in quincunx, but in curving, transverse bands, the number of teeth in a longitudinal series being about 160. A secondary pattern formed by the same teeth is a sequence of V's, each apex being directed posteriorly. There is no trace, however, of a true quincunxial formation, such as has been described by previous authors reporting on *Nemichthys* and found by us in both *Avocettina* and *Labichthys*. On each mandibular ramus there are six longitudinal rows of teeth arranged in a strongly oblique series of transverse rows directed forwards and inwards, so that when the two rami are approximated a V-shaped pattern is formed like that of the ethmo-vomer; the curving, transverse bands characteristic of the latter bone, however, are not evident, although here also, the obliqueness of the transverse rows throws the teeth far out of quincunxial arrangement. Because, perhaps, of the youth of the specimens, the teeth are relatively shorter and blunter than in either *Avocettina* or *Labichthys*, while the terminal swellings of both jaws, although distinctly present, are not as well developed as in the other genera.

Fins: Pectoral rays 11, their length contained 1.9 to 2.1 times in postorbital length, the first ray more strongly developed than the others, inserted at or slightly in front of the upper angle of the branchial cleft, below the second to sixth dorsal ray[4]. Dorsal rays about 405 to 450, about 100 of the median ones (from the 118th-148th ray to the 220th-252nd ray) being

[4] Instead of below the eleventh or twelfth dorsal ray, because of the immaturity of the specimens; as has been said, in larger specimens the dorsal originates even farther forward on the occiput.

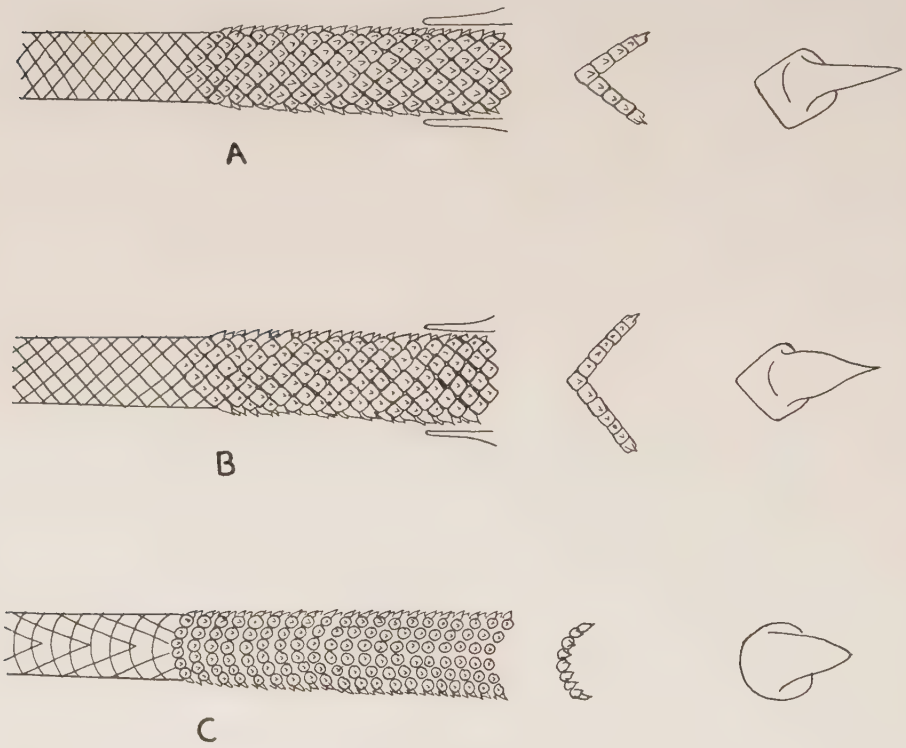


Text-figure 2.
Nemichthys scolopaceus. Head, lateral (upper) and dorsal (lower) views. Standard length 342 mm. (x 4.1).

reduced to spines by the breaking off of the delicate terminal portions of the rays; the last "spine" occurs about 15 rays in front of the origin of the caudal filament. Anal rays about 415 to 454, the longest in middle third of body, more than three times longer than dorsal rays and 25 % longer than maximum body depth; on the caudal filament both dorsal and anal rays are much shorter and more widely spaced than elsewhere, but along the entire length of the filament the rays, when unbroken, are 1.5 to 2 times the depth of the body at the corresponding point; in this caudal region, the anal rays are only slightly longer than the dorsal. Caudal rays five.

Vertebrae and Pores: There are about 450 vertebrae in a cleared and stained specimen 342 mm. in length, about 145 to 150 of them being included in the caudal filament. The characteristic pores, arranged quincunxially in three rows, are invisible in specimens examined in or out of the alcohol in which they have been preserved. After they have been soaked for half an hour or more in fresh water, however, the presence and pattern of the pores are clearly discernible under moderate magnification in at least the anterior part of the body; posteriorly they are so rudimentary that their numbers cannot be counted accurately.

Osteology: (Text-figs. 5-9). With the characteristics of the genus,



Text-figure 3.

Semi-diagrammatic representations of vomerine teeth in nemichthyid eels at broadest part of bone (near articulation with maxillary). The median vertical series represents single bands of teeth from the same sections of the vomer. Right-hand series shows single teeth, greatly enlarged. **A**, *Labichthys carinatus*, standard length 470 mm.; **B**, *Avocettina* sp., standard length 498 mm.; **C**, *Nemichthys scolopaceus*, standard length 357 mm.

which were derived from the cleared and stained 342 mm. specimen, one of the transitional adolescents under discussion. Immaturity is shown in the excessively slight degree of ossification, which is slight even for this delicately ossified family. The jaws alone show a moderate amount of stain, while the skull, opercular, hyoid and branchial apparatus show only a slight amount of bony matter and all the fins, their supports and the vertebral column are entirely unossified. Another indication of immaturity lies in the shape of the vertebrae, which are almost cylindrical. The simplicity of the tail, however (Text-fig. 9) is probably generic rather than juvenile.

Development.

(Text-figs. 4, 5).

Material: All stages, with the exception of the adult, are represented in the collection:

Larvae, 38 to 210 mm.: 10 specimens.

Post-larvae, 200 to 295 mm.: 13 specimens.

Adolescents, 240 to 312 mm.: 17 specimens.

Transitional adolescents, 300 to 360 mm.: 5 specimens.

Key to the Growth Stages: The following key will serve to distinguish the various growth stages, and to correlate them with the series described by Roule and Bertin (1929, pp. 67-96).

A. Body flattened laterally, its height much greater than its thickness and contained not more than 75 times in the length; translucent.

B. Depth in length 10-35; anal fin not in final position.

C. Larval fangs present; anal origin between 93rd and 257th myomeres, near end of body; no caudal filament. ..... *Larva* ("Leptocephale A").

CC. Larval fangs absent; anal origin between 256th and 7th myomeres, moving forward on body; caudal filament appearing. ..... *Post-larva* ("Tilurelle A," *partim.* and "Tilurelle B," *partim.*).

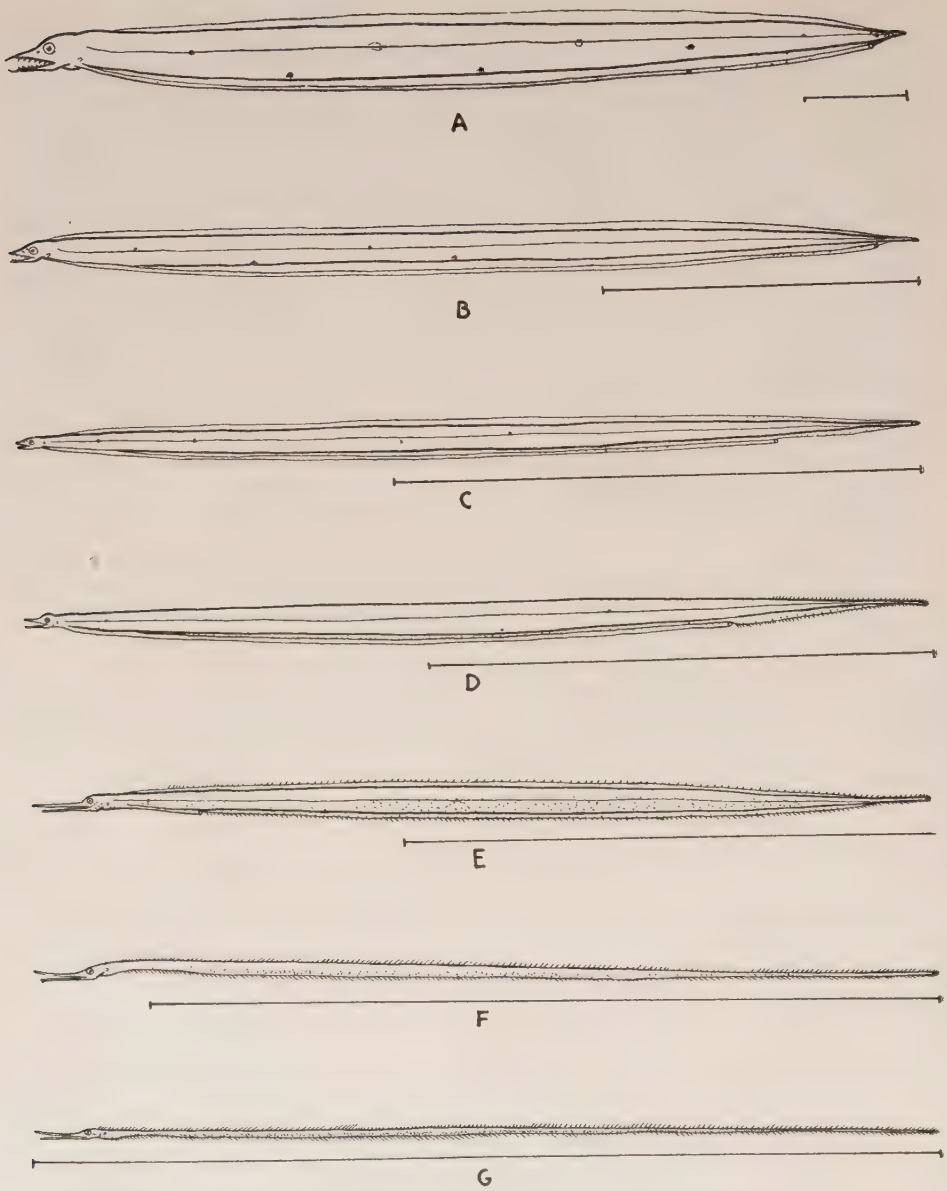
BB. Depth in length 60-75; anal fin in final position (at about 6th myomere) ..... *Adolescent* ("Jeunes *Nemichthys* transparents," *partim.*).

AA. Body rounded; slender (depth contained at least 120 times in the length; opaque.

D. Gonads developing; pigmentation, position of dorsal fins, ossification and dentition immature in earlier half of stage. ..... *Transitional Adolescent.*

E. Gonads mature ..... *Adult.*

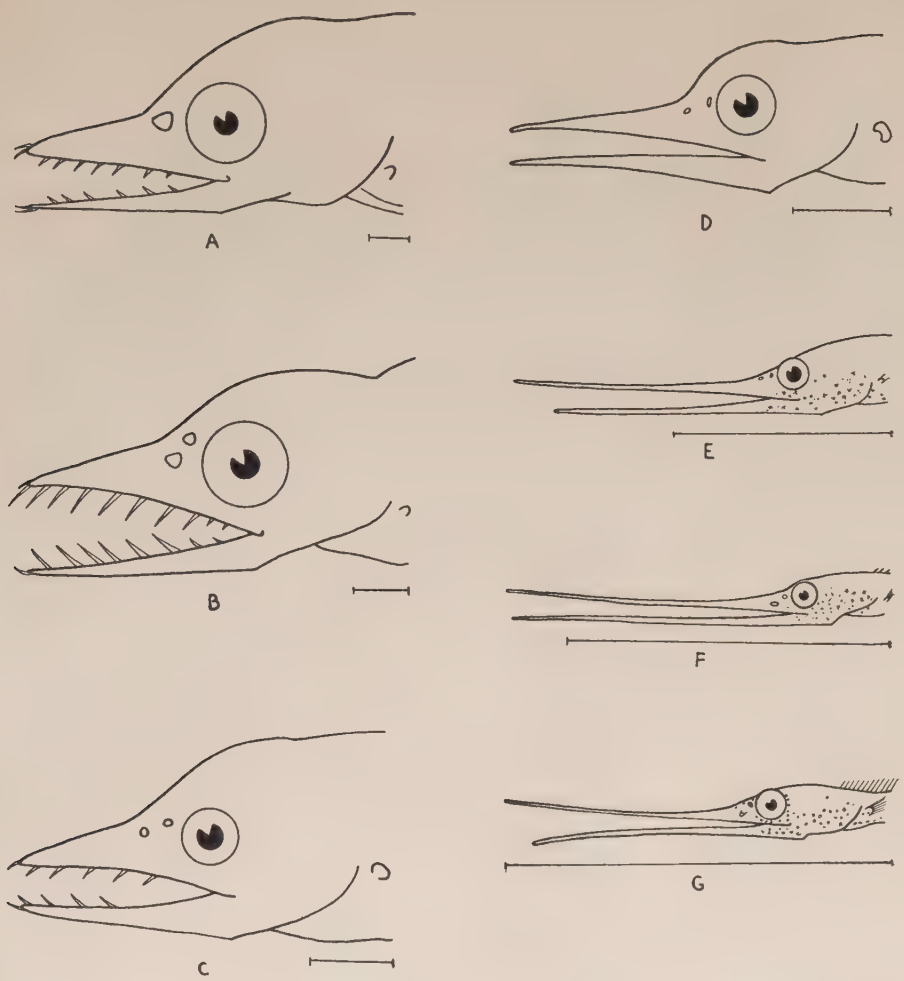
General Discussion: In 1929 Roule and Bertin (pp. 61 ff.) identified the larva of *Nemichthys* as a leptocephalus characterized chiefly by the presence of a great number of myomeres, posteriorly placed anus, mesenteric ligaments located in the same myomeres as in transformed specimens, long snout, and larval pigment spots on the medullary chord, along the intestine, and, post-anally, along the bases of the dorsal and anal fin. This general type they found to contain two forms; the first, designated as "Leptocephalus A," was characterized by the presence of four external, lateral pigment spots which always occurred at or near the 19th, 38th, 79th and 116th myomeres, by its smaller size range, and by the relatively small number of preanal myomeres. The second, designated as "Leptocephalus B," lacked all trace of the four lateral pigment spots, grew much larger before metamorphosing, and had a correspondingly large number of preanal myomeres.



Text-figure 4.

Nemichthys scolopaceus. **A** to **C**, incl., larvae, 40, 125 and 210 mm., respectively; **D** and **E**, post-larvae, 200 and 210 mm.; **F**, adolescent, 312 mm.; **G**, transitional adolescent, 357 mm.

It probably represented, Roule and Bertin decided, either another race of *Nemichthys scolopaceus* or a giant albino form of the same species, their identification resting largely on the positions of the mesenteric ligaments, the last one in each case being oblique and lying between the 83rd and 94th myomeres.



Text-figure 5.

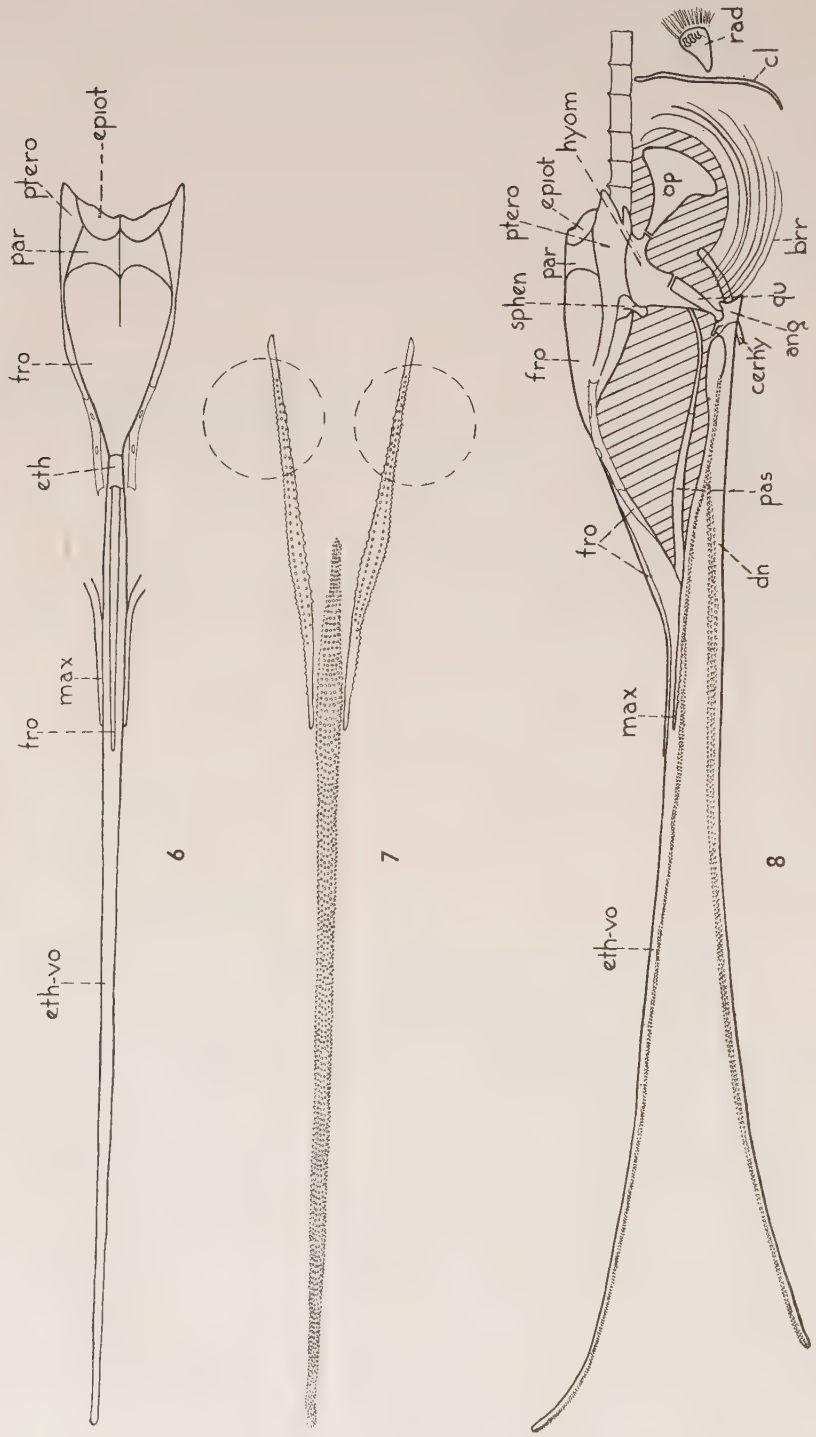
Nemichthys scolopaceus. **A** to **C**, incl., larvae, 40, 125 and 210 mm., respectively, in standard length; **D** and **E**, post-larvae, 200 and 210 mm.; **F**, adolescent, 312 mm.; **G**, transitional adolescent, 357 mm.

They further described six postlarvae ("Tilurelle A" and "Tilurelle B"), and three adolescents ("jeunes *Nemichthys* transparents") which show discrepancies both of size and coloration in the formation of the single series urged by these authors. All of these differences, however, they contend must be due to the variability of the species, and to the lack of sufficient material in the transforming, intermediate stages.

The following table will make these discrepancies clear:

Leptocephalus A, 664 specimens, length 9 to 253 mm., preanal myomeres 93 to 254.

Leptocephalus B, 26 specimens, length 32 to 359 mm., preanal myomeres 179 to 320.



Text-figures 6-8.

Nemichthys scolopaceus. **6.** Skull of transitional adolescent, dorsal view; standard length 342 mm. (x 7.1). **7.** Same, teeth of upper jaw and vomer, ventral view. (x 7.1). **8.** Same, bones of head, pectoral girdle and anterior part of vertebral column, lateral view. (x 7.1).

Tilurella A, 6 specimens, length 224 to 374 mm.; preanal myomeres 180 to 297.

Tilurella B, 4 specimens, length 230 to 286 mm.; preanal myomeres 70 to 39.

Young *Nemichthys,* transparent, 2 specimens, length 393, 413 mm.; preanal myomeres 6.

It will be seen that in Leptocephalus A the full range of preanal myomeres is from 93 to 257. The range for larger larvae (loc. cit., Table XV, p. 76), in which the anus has reached its most posterior position, is between 228 and 257 pre-anal myomeres; this stage being reached at 46 mm. In Leptocephalus B, on the other hand (loc. cit., Table XVI, p. 82), the full range is from 179 to 320 myomeres, the range for larger larvae being between 312 and 320 pre-anal myomeres, while this stage is not reached until 174 mm., the increase in pre-anal myomeres continuing until that point. Furthermore, the numbers in specimens of the same size—always one of the most important characters in the identification of larval eels—do not correspond in the two forms except in the smallest specimens: for example, the largest Leptocephalus A, at 253 mm., has 248 pre-anal myomeres, while two Leptocephalus B, of the corresponding lengths 231 mm. and 262 mm., have respectively 312 and 318 pre-anal myomeres.

Taking into account the minute specific differences between closely related leptocephali (e. g., between the larvae of *Anguilla anguilla* and of *Anguilla rostrata*) it seems clear that the differences between Leptocephali A and B of Roule and Bertin indicate that two entirely different species are involved, instead of merely two races, or normal and abnormal specimens. There seems no reason to suppose that either the general facies, the location of the last *bride mesentrique,* stressed by Roule and Bertin as constant in the two forms, or the fact that both "A" and "B" were often taken in the same net, prove that the forms are varieties of the same species; instead it seems much more probable that the form and position of the ligaments are family, or possibly, generic, characters.

The Tilurella A, ranging from 224 to 374 mm., also show discrepancies. The smallest is all of 135 mm. shorter than the largest larva of the Leptocephalus B type, while the following stage, Tilurella B, is represented by three specimens, all very short (230 to 286 mm.) compared with the longest Leptocephalus A and Tilurella A. Finally, the youngest adolescent specimens ("young transparent *Nemichthys*") mentioned, represent the earliest stage at which the dorsal and anal have reached their final positions and are, as the authors say, much farther advanced than the preceding stage, measuring 393 and 413 mm.—a length gap of more than 100 mm.

From a detailed study of the Bermuda material, we may confidently draw the following conclusions:

1. The careful description by Roule and Bertin of Leptocephalus A is perfectly applicable to our larvae, which make a continuous series, without either gaps or extensive overlappings in length, through post-larvae and adolescents to transitional adolescents of *Nemichthys,* presumably *N. scolopaceus.*

2. Roule and Bertin's Leptocephalus B belong to some other *Nemichthys*-like form, either *Cercomitus* or *Nematoprora,* or else to another species of *Nemichthys,* which is probably contained in the *Dana* collection—either the large-eyed or very small-eyed Atlantic form.

3. Their Tilurella A probably contains forms of both our species of *Nemichthys* (especially the smallest, in which Roule and Bertin were able to distinguish remains of the characteristic lateral chromatophores of Leptocephalus A, of which one or more of the possible four were distinguishable in every one of our post-larvae) and of the Leptocephalus B form, whatever that proves to be.

4. Doubtless some of the succeeding immature forms also belong to another species, either *Nemichthys* or a related genus, because of the following observations: Their smallest "adult" (i.e. transitional adolescent) measures only 215 mm. in length, while most of the deep-sea eels whose growth stages are known undergo the final steps of metamorphosis at about the same length within the species (*Serrivomer, Platuronides, Derichthys, Nessorhamphus*). In the second place, on p. 13 these authors state that the pigment of young *Nemichthys* develops tardily and, as in *Cercomitus* (Weber) appears first near the end of the caudal filament and in the region of the kidney; three of these forms they have figured on Pl. I, figs. 7, 8 and 9. They mention there are a few abnormal forms in which the pigment appears as "large black spots generally distributed on the ventral half of the body, as in their Pl. I, g. 10. Owing to the presence on three post-larvae in the present Bermuda collection of both typical larval lateral chromatophores and of the beginnings of general pigmentation in the form of superfical chromatophores on the ventral half of the body, it is certain that the "abnormal" specimen figured by them is in reality a true *Nemichthys* which has developed from a Leptocephalus A, since in adolescent specimens only slightly older, and with this same characteristic pigmentation, we have discovered the typical series of *Nemichthys* pores which Roule and Bertin found to appear only very tardily. The pores are, however, exceedingly difficult to see in these young specimens and not all of them are developed at this stage; sometimes they are distinguishable only after the alcoholic specimen has been soaked for an hour or two in fresh water; a moderately strong lens is, of course, necessary.

5. The following synonymy of *Nemichthys* leptocephali and immature forms may now be made:

Nemichthys scolopaceus:

Leptocephalus andreae Schmidt, 1912.
Leptocephalus canaricus Lea, 1913.
Tilurella nemichthydis scolopacei Roule, 1914, 1919.
Tilurella gaussiana Pappenheim, 1914.
Nemichthys scolopaceus, Leptocephalus A, Roule and Bertin, 1929.
Nemichthys scolopaceus, Tilurella A, Roule and Bertin, 1929 (*partim*).
Nemichthys scolopaceus, Tilurella B, Roule and Bertin, 1929 (*partim*).
Nemichthys scolopaceus, young transparent *Nemichthys,* Roule and Bertin, 1929 (*partim*).
Nemichthys infans, Borodin, 1931.
Tilurella Nemichthydis infantis, Borodin, 1931.
Serrivomer sector, Borodin, 1931.

Diagnostic Description of the Growth Stages: The characteristics of the growth stages are summarized below. For a thorough description of the larva, consult Roule and Bertin's description of Leptocephalus A (1929, pp. 68-81). For a description of the internal organs of subsequent stages, see the same source, pp. 86, 89.

Larva: (Text-figs. 4 A-C, 5 A-C). Pigment: This is found in four groups of chromatophores, the first two tending to disappear in older larvae, the last two becoming more noticeable with age: 1. A conspicuous chromatophore situated between the lateral mid-line and the ventral profile at or about the 19th, 38th, 79th and 116th myomeres. Of these, the first usually placed almost in the lateral mid-line, is the most constant; it has been found even in advanced post-larvae. 2. A series of internal spots on the spinal chord, which become more numerous with age; in small specimens there are usually three conspicuous ones, visible externally, through the skin,

in or near the 55th, 92nd and 145th myomeres. 3. A series of minute chromatophores on the dorsal surface of the intestine; in young specimens these are present on the posterior portion only, becoming more numerous and more extensive anteriorly with age. 4. A series of minute chromatophores on the dorsal and anal finfolds at the base of the developing dorsal and anal rays. These, too, increase in number with the development of the fins. In the very youngest larvae in the collection they are represented by less than half a dozen conspicuous spots posterior to the anus above and below the lateral mid-line.

Proportions: Depth (measured to exclude intestines and finfolds) 9 to 25 in length (11 % to 4 %). Head in length 8 to 40 (12.5 % to 2.5 %), largest in youngest specimens. Eye 4 to 5 in head, decreasing in size relative to the trunk with growth, almost round even in young specimens. Snout long, slender, longer than postorbital distance measured from posterior margin of eye to base of pectoral fin; profile of snout very broadly V-shaped, owing to a depression at level of nostrils; depth of head relative to its length almost constant throughout larval stage; supraorbital distance moderately great—not excessive as in serrivomerid larvae; highest point of head above posterior part of eye or just behind it; tips of jaws equal, or upper projecting very slightly; jaw angle under middle of eye in oldest specimens; this change in position is due partly to the relative decrease in the size of the eye and partly to an actual prolongation of the jaw.

Teeth: One or two pairs of long, slightly curved, fang-like larval teeth at tips of both jaws, each tooth being followed by four to nine similar ones, usually longer than the terminal fangs. The teeth are relatively longest in half-grown larvae (around 125 mm. in length); in fish of this length the teeth are all about of equal size (more than one-third longer than eye diameter), except for the first fangs and the last two pairs, which usually are somewhat smaller. As in other leptocephali, the larval teeth drop out gradually as the time for metamorphosis approaches, at a length of around 210 mm., until, in post-larvae, when the migration of the anal commences, they are completely lacking.

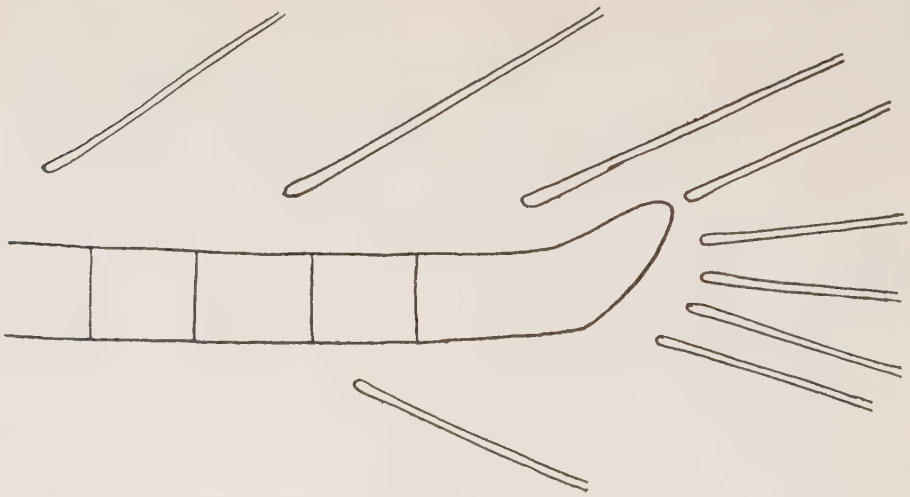
Fins: Pectoral small, fan-like, without true rays, typically larval; anal very short, occupying in young larvae the last one-twentieth of fish, in grown larvae, one-sixth (because of the increase in caudal myomeres alone, since the forward migration of the anus has not yet begun). Dorsal fins about equal in length to anal, sometimes extending slightly farther forward; rays of both fins only rudimentary in even the largest larvae. Dorsal and anal finfolds extending throughout length of body behind the nape, and behind the heart below the intestine, respectively. Caudal rays invisible in larvae, the finfolds dying out just before the very slender, pointed tip of the posterior end of the body.

Myomeral Count and Length Range: In the larva there is a total of about 100 to 450 myomeres, of which about 93 to 254 lie in front of the anus; the typical pre-anal count of about 230 to 254 is reached at about a length of around 65 mm. As has been said, the post-anal myomeres continue to increase throughout development. Roule and Bertin (loc. cit.) show that the extreme length range of the larva (Leptocephalus A) is from 9 to 253 mm.; our small series of 10 specimens range from 38 to 210 mm.

Post-larvae: (Text-figs. 4 D-E, 5 D-E). Examples of this stage in the present collection measure from 200 to 295 mm. As in other eels, during the post-larval and adolescent stages, the actual transformation from leptocephalus to anguilliform takes place. The post-larva differs from the larva most obviously in the loss of larval teeth, the gradual elongation and slenderizing of the snout, in the continued reduction of the relative size of the eye, and in the forward migration of the vertical fins, with a corresponding shortening and, later, the bending of the intestine. The individual finrays, though very short, become distinctly visible in this stage, the dorsal and

anal being still suspended above and below the body proper by finfolds, although the intestine is more closely approximated to the body than in the larva. In relative depth there is little change, although a slight increase in thickness takes place. The internal medullary and the intestinal pigment spots increase in number, while most of the external lateral characteristic pigment spots, near the 19th, 38th, 79th and 116 myomeres, are often lacking, although at least one, usually the first, remains in even the most advanced specimens. In these oldest post-larvae there are present, in addition to the larval spots, dendritic, adult chromatophores on the ventral half of the body. They extend from the postorbital region back as far as about the beginning of the last seventh of the body; the last seventh lacks all trace of pigment, proving that the *Dana* specimens in which pigment developed first in this position must have belonged to another species (see p. 361).

Adolescent: (Text-figs. 4 F, 5 F). Examples of this stage in the present collection range from 240 to 312 mm. The adolescent differs from the post-larva primarily in the fact that the anus, and with it the anal fin, has reached its final position immediately behind the base of the pectoral fin. It differs from the adolescent stage of other fishes in that the dorsal fin is not similarly completed: while it has already reached a position well in front of the pectoral, it continues to migrate slowly forward throughout not only adolescence, but transitional adolescence as well, until it reaches its characteristic position far forward on the occiput. The form of this adolescent stage is somewhat semi-leptocephalid (depth in length about 60 to 75, or 1.65 % to 1.34 %), although the fins are scarcely suspended above and below the profiles any more, and the body has thickened slightly. The depth is about half that found in post-larvae and twice that of transitional adolescents. The snout and jaw are typically nemichthyidiform, while the eye and postorbital distance are reduced to about their final relative small size in respect to the length of the head. The teeth are rudimentary. The caudal filament is distinguishable, though it is not as well marked as in the succeeding stage. The characteristic short, spinous finrays of the median part of the dorsal are not yet distinguishable. When the adolescents are soaked in water, typical series of *Nemichthys* pores become visible in the



Text-figure 9.

Nemichthys scolopaceus. Posterior part of vertebral column and base of caudal fin in transitional adolescent, standard length 342 mm. Greatly enlarged.

anterior part of the body. The larval pigment spots are absent, though the internal, medullary spots are still present, as well as those on the dorsal side of the now practically enclosed intestine. Adult pigment continues to develop on the lower half of the body, except on the end of the caudal filament.

Transitional Adolescent: (Text-figs. 4 G, 5 G). Examples of this stage in the present collection, ranging from 300 to 360 mm., have already been discussed, on pp. 353 to 357. In relation to development, it will be seen that transitional adolescents differ from members of the preceding stage chiefly in the completely anguilliform proportions of the body, in the development of the teeth, in the spiniform aspect of the median rays of the dorsal fin and the elongation of the other finrays, and, finally, in the increase in pigmentation (in this stage there appears for the first time a slight amount of pigment on the lower part of even the end of the caudal filament). The immaturity of the specimens is shown in the incomplete pigmentation, in the fact that the dorsal fin has not quite reached its final position on the occiput, in the small degree of ossification, and, finally, in the immaturity of the gonads. The number of vertebrae in the caudal filament probably continues to increase throughout life.

Ecology.

Seasonal Distribution: About half of the Bermuda specimens were taken in September, although the trawling season extended from April to September. These September examples included post-larvae, adolescents and transitional adolescents, but no larvae, the latter having all been taken earlier in the season.

Vertical Distribution: Except for two larvae, one at 50 fathoms and one at 400 fathoms, *Nemichthys* was taken only between 500 and 1,000 fathoms. Six-inch *nemichthyids*, however, were observed from the bathysphere at a depth of 75 fathoms.

Abundance: Next to *Serrivomer beanii* and *Eurypharynx pelecanoides*, *Nemichthys* is the most common deep-sea eel found in our Bermuda trawling area, 45 specimens having been taken in the nets. Among the Bermuda deep-sea fishes in general, however, the species is rare.

Sociability: Two *Nemichthys* came up in the same net on only four occasions. The three six-inch nemichthyids seen from the bathysphere were swimming in a group.

Food: Six of the larger specimens examined for food all had empty stomachs.

Viability: No *Nemichthys* has been taken alive.

Study Material.

The following list gives the catalogue number, net, depth in fathoms, date, length and growth stage of each specimen of *Nemichthys scolopaceus* taken by the Bermuda Oceanographic Expeditions. All were caught in the cylinder of water off the Bermuda coast described in *Zoologica*, Vol. XVI, No. 1, p. 5 and Vol. XX, No. 1, p. 1. "Trans. Adol." stands for "Transitional Adolescent."

No. 9,675; Net 49; 800 F.; Apr 29, 1929; 156 mm.; Larva.
No. 9,726; Net 56; 1,000 F.; April 30, 1929; 200 m.; Post-larva.
No. 11,015; Net 226; 700 F.; June 27, 1929; 104 mm.; Larva.
No. 11,074; Net 229; 1,000 F.; June 27, 1929; 45 mm.; Larva.
No. 11,353; Net 268; 700 F.; July 8, 1929; 242 mm.; Post-larva.
No. 11,692; Net 310; 600 F.; July 22, 1929; 230 mm.; Post-larva.

No. 12,438; Net 375; 800 F.; Aug. 15, 1929; 240 mm.; Post-larva.
No. 13,162; Net 430; 500 F.; Sept. 6, 1929; 202 mm.; Post-larva.
No. 13,513; Net 474; 700 F.; Sept. 9, 1929; ca. 300 mm.; Trans. Adol.
No. 13,644; Net 487; 800 F.; Sept. 21, 1929; ca. 240, ca. 285 mm.; Adolescents.
No. 13,709; Net 495; 800 F.; Sept. 23, 1929; 232, 294 mm.; Post-larva & Adolescent.
No. 13,754; Net 499; 800 F.; Sept. 24, 1929; 295 mm.; Adolescent.
No. 13,797; Net 505; 600 F.; Sept. 25, 1929; 357 mm.; Trans. Adol.
No. 14,850; Net 563; 600 F.; May 10, 1930; 38 mm.; Larva.
No. 15,302; Net 621; 600 F.; May 22, 1930; 40, 125 mm.; Larvae.
No. 15,459; Net 639; 700 F.; May 28, 1930; 312 mm.; Adolescent.
No. 17,153; Net 762; 1,000 F.; July 2, 1930; 245 mm.; Adolescent.
No. 16,957; Net 778; 700 F.; July 5, 1930; 245 mm.; Post-larva.
No. 16,955; Net 796; 1,000 F.; July 9, 1930; 210, 295 mm.; Larva, Post-larva.
No. 17,412; Net 810; 600 F.; Aug. 28, 1930; 253 mm.; Adolescent.
No. 17,413; Net 812; 600 F.; Aug. 28, 1930; 255 mm.; Adolescent.
No. 17,522; Net 824; 800 F.; Sept. 1, 1930; ca. 245 mm.; Adolescent.
No. 17,747; Net 834; 400 F.; Sept. 3, 1930; 226 mm.; Post-larva.
No. 17,786; Net 838; 600 F.; Sept. 3, 1930; 260 mm.; Adolescent.
No. 17,820; Net 842; 600 F.; Sept. 4, 1930; 305 mm.; Adolescent.
No. 18,004; Net 853; 500 F.; Sept. 6, 1930; 342 mm.; Trans. Adol.
No. 18,025; Net 855; 700 F.; Sept. 6, 1930; 220 mm.; Post-larva.
No. 18,066; Net 859; 500 F.; Sept. 8, 1930; 292 mm.; Adolescent.
No. 18,316; Net 867; 800 F.; Sept. 10, 1930; ca. 300 m.; Trans. Adol.
No. 18,451; Net 880; 500 F.; Sept. 12, 1930; 240 mm.; Adolescent.
No. 18,637; Net 893; 900 F.; Sept. 15, 1930; ca. 230 mm.; Post-larva.
No. 19,380; Net 946; 600 F.; Sept. 25, 1930; 235 mm.; Post-larva.
No. 19,477; Net 955; 1,000 F.; Sept. 28, 1930; 342 mm.; Trans. Adol.
No. 19,973; Net 967; 500 F.; Sept. 30, 1930; ca. 240 mm.; Adolescent.
No. 20,856; Net 1014; 400 F.; June 13, 1931; 85 mm.; Larva.
No. 21,002; Net 1041; 50 F.; June 26, 1931; 41 mm.; Larva.
No. 21,982; Net 1141; 800 F.; July 6, 1931; 184 mm.; Larva.
No. 22,310; Net 1161; 500 F.; Aug. 11, 1931; ca 250 mm.; Adolescent.
No. 22,750; Net 1195; 800 F.; Aug. 18, 1931; 210 mm.; Post-larva.
No. 23,293; Net 1283; 600 F.; Sept. 10, 1931; ca. 240 mm.; Adolescent.
No. 23,613; Net 1305; 500 F.; Sept. 15, 1931; 249 mm.; Adolescent.

Genus ***Avocettina*** Jordan and Davis, 1888.

Generic Characters: Nemichthyids with a single row of pores in the lateral line and the anus located far behind the level of pectoral base; caudal filament absent; teeth quincunxially arranged in straight rows; dorsal origin immediately behind level of pectoral base; dorsal rays in middle third of body neither short nor spinous.

Parietals separated by suture; supraoccipital absent; pterygoid vestigial, slender; mandible much shorter than ethmo-vomer; all opercular bones except preopercle present, although only feebly ossified; hyoid and branchial apparatus either moderately or very little ossified; a single hypohyal; ceratohyal short, distinct from epihyal from which arise the 7 to 12 branchiostegals, which are either short, or long and strongly curved; glossohyal, rudimentary or absent; urohyal slender, bifid basally; one or no basibranchial; both upper and lower coracoid present; four radials; vertebrae about 170 to 198; neuropophyses of caudal vertebrae spinous, arising from middle of centrum; three hypurals.

Discussion: Including Günther's description of the type species in 1878, five species of *Avocettina* have been described; namely, *A. infans* (Günther), 1878; *A. elongata* (Gill and Ryder), 1883; *A. gilli* (Bean), 1890; *A. bowersii* (Garman), 1899; and *A. exophthalma* Parr, 1932. Of these, *A. infans, A. elongata* and *A. exophthalma* were described from specimens taken in the Atlantic, while *A. gilli* and *A. bowersii* were from the eastern Pacific, having been caught off Alaska and Central America, respectively. Examples taken in the East Indies and Indian Ocean were referred by Brauer (1906) and Weber (1913) to the type species, *A. infans,* as were additional specimens recorded from the Atlantic by Jordon and Davis (1888), Norman (1930), Parr, with a query, (1932) and Roule (1933)[5]. We have examined at the Museum of Comparative Zoology the specimens referred by Borodin (1931) to *Nemichthys infans* and *Tilurella Nemichthydis infantis;* because of their characteristic myomeralcounts, larval pigment spots and rudimentary, but distinct, caudal filaments, we identify them as post-larval and adolescent examples of *Nemichthys scolopaceus.*

In the meantime Roule and Bertin (1929), having studied the 34 specimens taken by the *Dana* in the Atlantic and eastern Pacific, referred them all to *A. infans,* submitting the opinion that *A. infans, A. elongata, A. gilli,* and, more questionably, *A. bowersii,* were all probably synonymous. (*A. exophthalma* had not yet been described at the time of their work). Although settlement of the question will have to await a comparison of new material with the extensive *Dana* collection, as well as with the specimens from the East Indies and the Indian Ocean, nevertheless we have gathered evidence to show first, that *A. elongatus* is synonymous with *A. infans;* second, that the establishment of the validity of *A. gilli* must await a proper redefinition of *A. infans,* although the two are probably distinct; third, that *A. bowersii* is valid; and fourth, that probably at least one other species, as yet undescribed, has been already taken in the Atlantic. The single Bermuda specimen is included in the latter category.

In reaching these conclusions the following specimens in other collections have been examined:

1. *A. elongata* (Gill and Ryder), 1883: The unique specimen has been reexamined at the United States National Museum. Unfortunately, it is in very poor condition, with the upper jaw broken off short, the mandible missing entirely; the branchial and pectoral regions damaged; both pectoral fins, attached to a loose and twisted strip of abdominal skin, pulled far back out of place; and the first anal finrays uncountable. For these reasons, the only satisfactory proportion that could be taken was that of the interorbital breadth to the eye, in which it is contained about 1.9 times. A total of 198 pores was counted in the lateral line; supposing the usual number of about four pores to occur before the pectoral origin, a total of 194 pores are present on the trunk. The all important proportion of eye into postorbital distance cannot be determined because of the hopelessly damaged pectoral region; all that can be said is that the eye and postorbital both appear to be moderate—that the first is contained in the second, say, somewhere around three times. In spite of the somewhat large number of pores in the lateral line, it seems best, since the pores were not counted in the type specimen of *A. infans,* to emphasize the narrow interorbital and apparently moderate postorbital and eye, and synonymize *A. elongata* with *A. infans.*

2. *A. gilli* (Bean), 1890: The unique specimen of this Alaskan species also was examined at the United States National Museum. As in *A. elongata,* both jaws are broken off short, so that most measurements could not be taken. The eye is contained in the postorbital about 2.2 times, the interorbital in the eye more than twice. There are 177 or 178 pores in the

[5] When he found that the type specimen of *Gavialiceps tinayrei* Zugmayer (1914) was a typical *Avocettina.*

lateral line behind the pectoral origin and three in front of it. The anal originates at the vertical between the eighteenth and nineteenth pores behind the pectoral base. Accurate branchiostegal and finray counts cannot be secured without careful dissection or staining. With *A. infans* established as the variable species it is now understood to be, *A. gilli* may actually prove to be synonymous with it. It seems far more likely, however, that it will prove to be a distinct species, as is often found to be the case, with so-called cosmopolitan forms from the Pacific, when sufficient material becomes available. In any case, *A. gilli* is distinct both from the Atlantic *A. exophthalma,* characterized by the broad interorbital space, and from the small-eyed Pacific form, *A. bowersii.*

3. *A. bowersii* (Garman), 1899: The type specimen was examined at the Museum of Comparative Zoology, and Garman's original description and figure found to be accurate. Specimens taken by the Templeton Crocker Expedition of the New York Zoological Society off the coast of Lower California added as a further check to the unquestionable validity of this very distinct form with small eyes, many branchiostegals and few dorsal rays. Without doubt the *Dana* specimens from Panama recorded by Roule and Bertin belong also to this species (Roule and Bertin, 1929, p. 26, Table VI, nos. 6 to 15, 17-20, 24-27 and 29[6]).

In regard to the remaining species, *A. exophthalma* and *A. infans,* of which the types have not been examined, the following conclusions are drawn:

A. exophthalma Parr, 1932: This West Indian species with its wide interorbital space and large eye is almost certainly valid. It is likely that Specimen No. 3 of Roule and Bertin, and possibly also their young Specimen No. 30, belong to this species.

A. infans Günther, 1878: The type species, left to include the remaining known specimens, still embraces exceptionally diverse examples. Even when the Panamanian species of Roule and Bertin, and those mentioned above under *A. exophthalma,* are omitted from the list, there are still such wide variations in the proportions of remaining Atlantic specimens that it seems that more than one species must be involved. An example is the variability of the eye, which is contained in the postorbital distance 2.8 to 4.7 times. Although the latter figure is typical of the Pacific species, *A. bowersii,* still that form is distinguished by the fewer number of dorsal finrays (around 255 instead of around 340).

In the following study, the single Bermuda specimen is shown to differ from apparently typical *A. infans* in its greater interorbital width, larger eye, longer snout and smaller postorbital distance. For the following reasons, however, it is not designated as the type of a new species: First, it is intermediate in position between *A. infans* and *A. exophthalma.* Secondly, the type material of *A. infans* requires a reexamination, in the light of the material which has accumulated since the publication of the description. Thirdly, it is probable that Specimen No. 23 of Roule and Bertin from the West Indies belongs to the same species as the Bermuda specimen, if the latter does prove to be distinct. The same may be true of their Specimen No. 21, of one or both of Günther's smaller specimens and of Parr's (1932) damaged, 390 mm. example. This material should all be examined before a new species is established especially because, fourth and finally, the Bermuda specimen is in poor condition due to unforeseen decomposition in clearing and staining (after measurements were made), and it seems inadvisable to designate it as the type of a new species in a genus already so confused. It is hoped that the following description, which is

[6] No. 28 from Panama does not agree, as Parr has already pointed out (1932, pp. 11-12). The localities of the numbered *Dana* specimens have been determined from a comparison of their lengths with specimens of corresponding lengths tabulated geographically in Roule and Bertin, 1929, p. 27, Table VII.

complete save for the dorsal fin count, will leave no doubt as to the specimen's proper taxonomic position when more material is gathered and the question settled.

Avocettina sp.

SPECIMEN TAKEN BY THE BERMUDA OCEANOGRAPHIC EXPEDITIONS.

1 specimen; July 2, 1930; 1,000 fathoms; from a cylinder of water 8 miles in diameter (5 to 13 miles south of Nonsuch Island, Bermuda), the center of which is at 32° 12′ N. Lat., 64° 36′ W. Long.; standard length 498 mm.

DESCRIPTION.

(Text-figs. 10, 11).

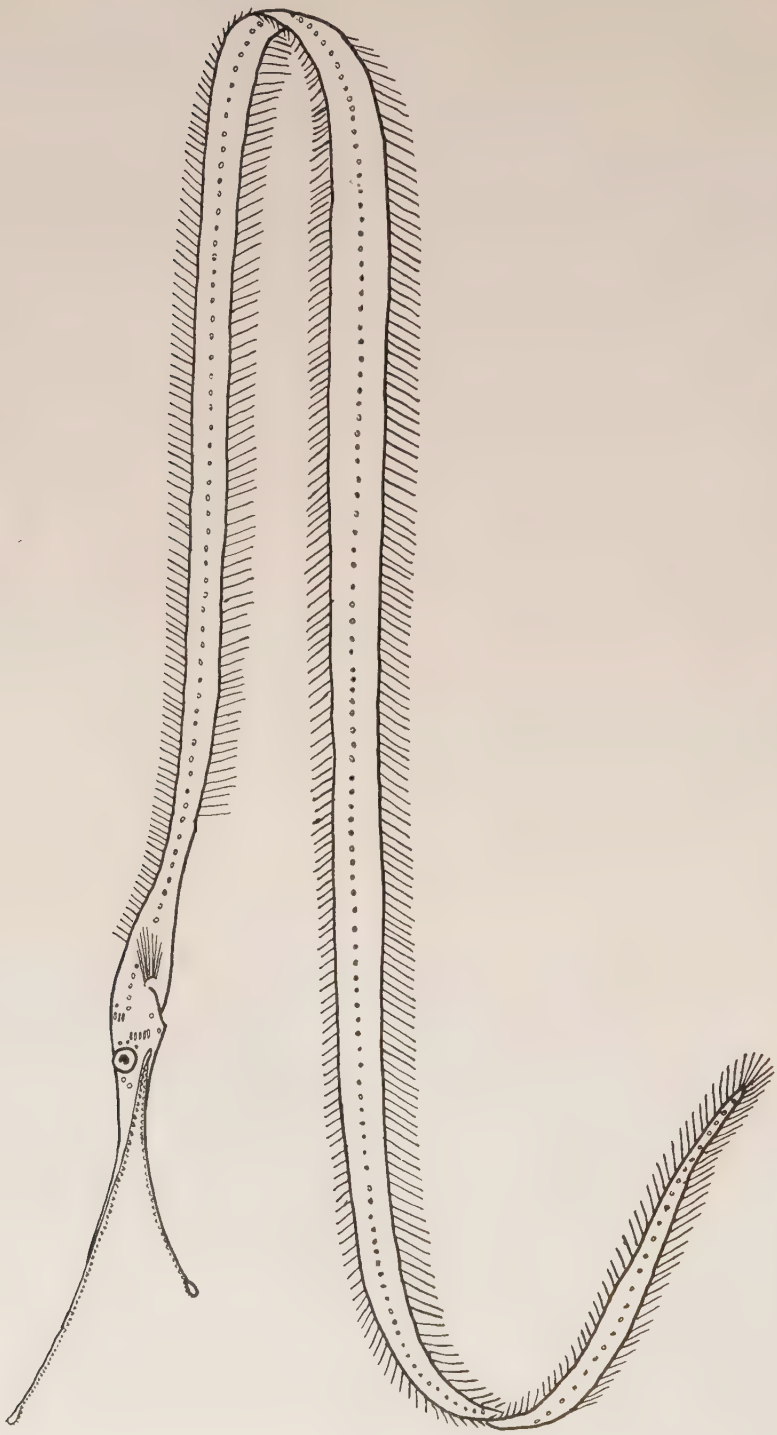
(With comparative notes on specimens of *Avocettina bowersii* from the Pacific).

Color of Fresh Specimen: Dark brown, spotted ventrally with black.

Measurements and Proportions: Length 498 mm.; depth at pectoral base 7 mm. (in length 71.1 or 1.4 %); maximum depth (187 mm. in front of end of tail) 8 mm. (in length 62.3 or 1.6 %); minimum depth (30 mm. behind eye) 3.5 mm. (in length 142 or 0.7 %); head 63 mm. (in length 7.9 or 12.7 %); eye 3.66 mm. (in head 17.2, in postorbital 2.4, 0.74 % of length); snout 53.4 mm. (in head 1.2, 10.7 % of length); postorbital 8.6 mm. (in head 7.3, in snout 6.2, 1.73 % of length); interorbital 3.2 mm. (in head 19.7, in eye 1.1, 0.64 % of length); tip of snout to posterior end of maxillary 57.5 mm., extending slightly behind posterior margin of orbit; tip of mandible to angle of jaw 36.5 mm.; tip of snout to tip of mandible 15.7 mm. (in snout 3.4, 3.2 % of length); pectoral base to dorsal origin 5.2 mm. (in postorbital 1.7, 1.04 % of length); pectoral base to anal origin 43 mm. (5 times postorbital length of head, 8.6 % of length); pectoral length 9 mm.; caudal length 4.4 mm.

Teeth: (Text-figs. 3B, 12, 13, 14). The entire inner face of the flattened maxillary is covered with minute, backwardly directed teeth arranged irregularly in quincunx: along the slender anterior edge they form a single row; farther back, at the widest portion of the bone, there are 12 rows, while at the posterior end the number is reduced to six. The teeth on the mandible and ethmo-vomer are larger and directed more sharply backward than those on the maxillary. The upper surface of the mandible and the lower surface of the ethmo-vomer are both strongly arched, their reverse sides being flattened; the teeth on both bones cover the entire surface of the arch, extending halfway or more to the border of the flattened surface, except near the anterior end. Here, where the bones become very slender and laterally compressed, the teeth are reduced to a single row along the apex. Beyond this point are the well-defined, swollen terminal knobs, both the upper and lower being well provided with irregularly set teeth. Both in this species and in a 431 mm. specimen of *Avocettina bowersii* taken off Lower California (see p. 374, Specimen No. 24,795, for data) there are at the broadest portion of the bones 13 rows of teeth, arranged in perfect quincunx, on both the ethmo-vomer and the mandible. In the present specimen about 260 teeth are placed in the mid-line of the ethmo-vomer posterior to the terminal knob.

Fins: Pectoral rays 17, originating under third to fourth lateral line pore, the first ray expanded and strongly developed, the second similar, but strengthened to a lesser degree. Dorsal and anal rays damaged, not countable; dorsal origin behind pectoral base above sixth lateral line pore

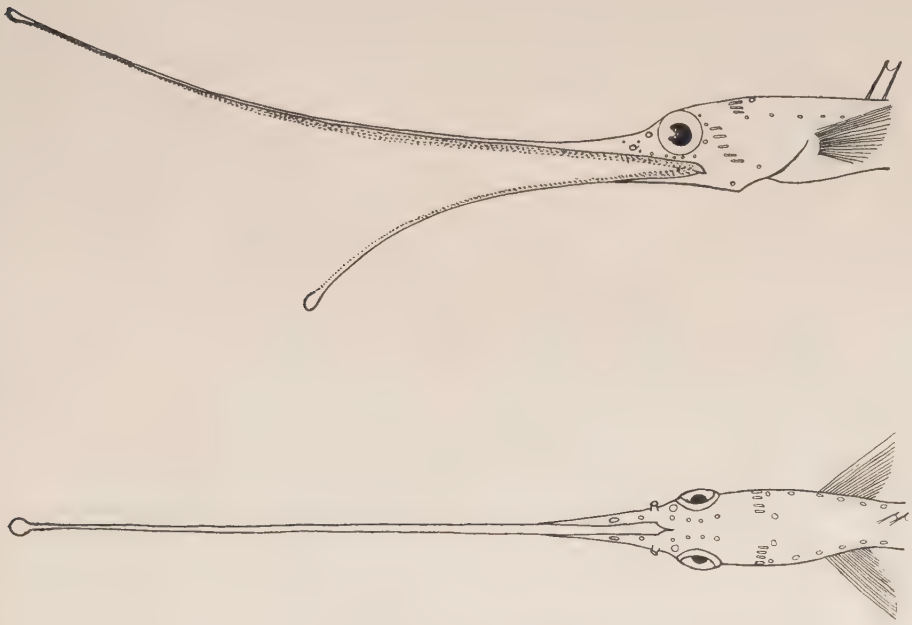


Text-figure 10.
Avocettina sp. Standard length 498 mm. The complete numbers of fin rays are not indicated.

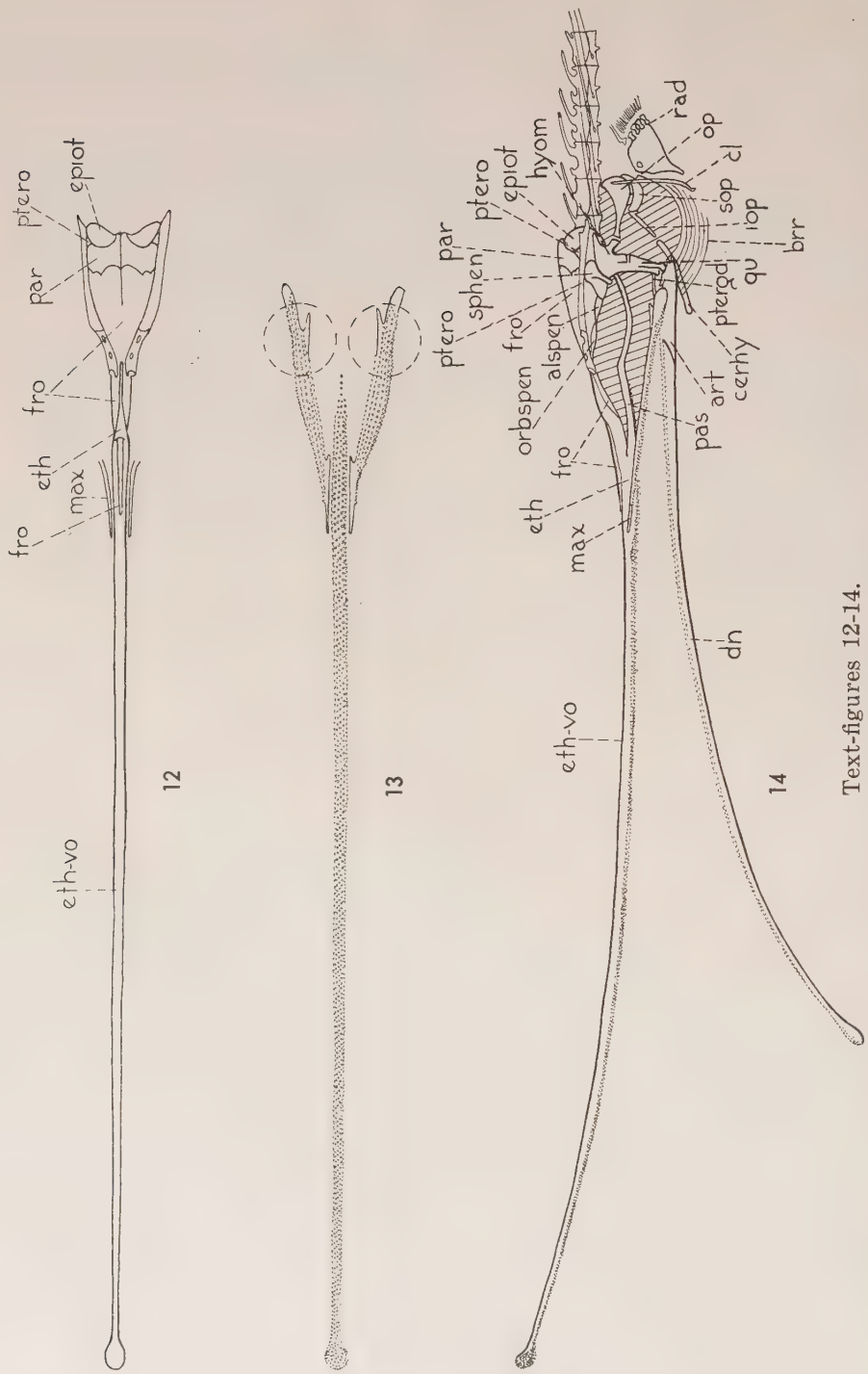
(third behind pectoral origin); anal origin under twenty-third lateral line pore (twentieth behind pectoral origin). Except for the first, short rays, the dorsal and anal rays both are longest in the anterior two-thirds of the body; anal rays about twice as long as dorsal, more than half maximum depth of body at that point. Caudal rays five.

Pores and Vertebrae: There were 195 pores in the lateral line, the first three occurring in front of the pectoral base. Because of the decomposition of the trunk during clearing, it is impossible to count the vertebrae; however, in the specimen of *Avocettina bowersii* mentioned above, the number of vertebrae exactly coincided with the total number of lateral line pores (175), so that in all probability equally similar results would have been obtained could the vertebral count have been obtained for the Bermuda specimen.

Osteology: (Text-figs. 12-16). With the characteristics of the genus. Hyoid apparatus very feebly ossified; seven short branchiostegals, corresponding to the lack of space between pectoral and opercle—i.e., the shortness of the postorbital region. (The specimen described by Trewavas (1932, p. 650) had the branchiostegals "much bowed," while those of *Avocettina bowersii* are similarly bowed, and very long in addition, corresponding to the more spacious postorbital region). Branchial apparatus entirely cartilaginous except for moderately well ossified pharyngobranchials. (In *Avocettina bowersii* the entire hyoid and branchial apparatus, though composed of delicately slender bones, are well ossified). Cleithrum at level of second vertebra, first pectoral ray at end of third. (In *Avocettina bowersii* the cleithrum is more slender, and falls at the level of the fifth vertebra, while the first pectoral ray is underneath the sixth). The vertebral column is almost entirely unossified, although the dorsal and anal rays, the pectoral fin, and all fin supports show moderate amounts of ossification. This is all in contrast to the skeleton of *Avocettina bowersii*, which is relatively well

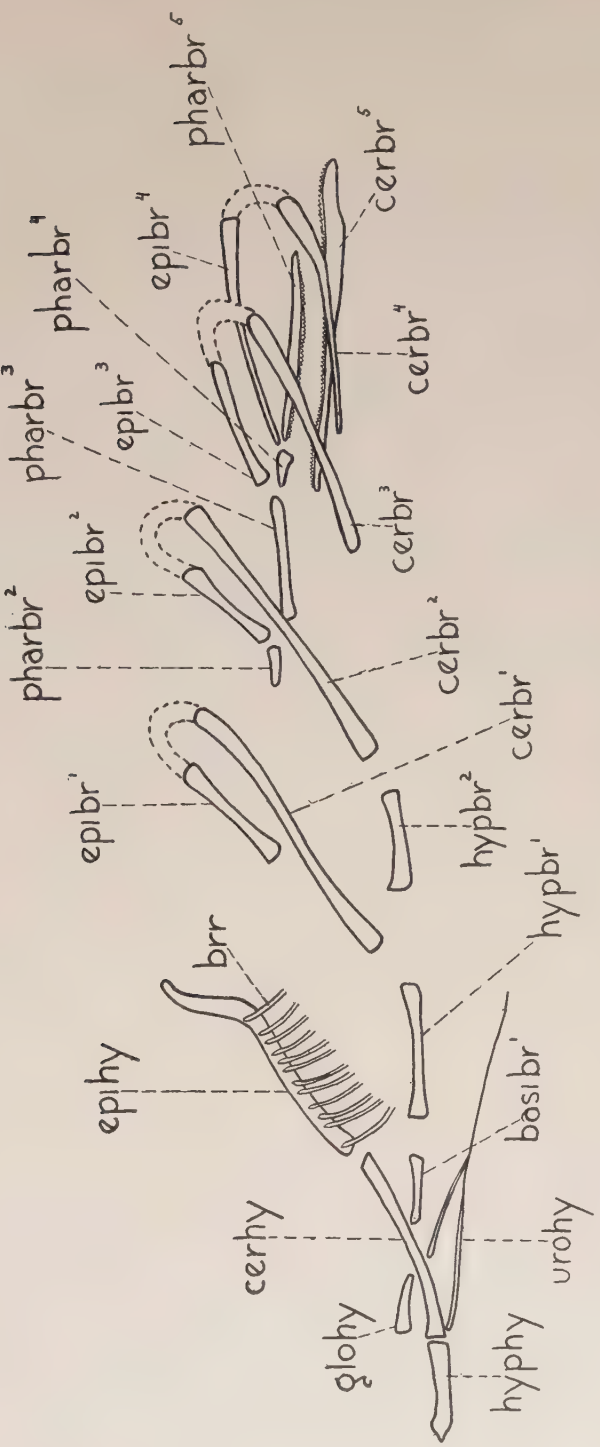


Text-figure 11.
Avocettina sp. Head, lateral (upper) and dorsal (lower) views. Standard length 498 mm. (x 1.6).



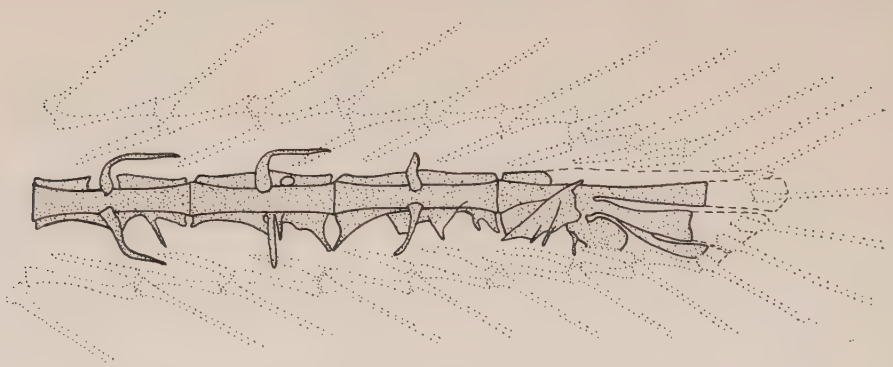
Text-figures 12-14.

Avocettina sp. **12.** Skull of adult, dorsal view; standard length 498 mm. (x 2.6). **13.** Same, teeth of upper jaw and vomer, ventral view. (x 2.6). **14.** Same, bones of head, pectoral girdle and anterior part of vertebral column, lateral view. (x 2.6).



Text-figure 15.

Avocettina sp. Hyoid and branchial apparatus of adult, standard length 498 mm. (x 18.4).



Text-figure 16.
Avocettina bowersii. Posterior part of vertebral column and base of caudal fin in adult, standard length 431 mm. (x 17.5).

ossified throughout. Since the tail of the Bermuda specimen of *Avocettina* sp. disintegrated during the clearing and staining process, a figure of the caudal vertebrae of *Avocettina bowersii* is included in this paper (Text-fig. 16). The tails of two specimens of this species were examined—that of the one referred to above, and another, slightly smaller example (for data see below, Specimen No. 25,783), and were found to be practically identical, both in the strong degree of ossification of the vertebrae, finrays and supports and in structure. The characteristic elements of the latter are the three hypurals and the irregular flange of bone directed forward and downward which arises on each side of the last vertebra. The neural spines arise from the center of the centrum, not from the posterior portions, as Trewavas states is the case in *Nematoprora polygonifera* (loc. cit. p. 649).

Coelomic Organs: With the characteristics of the family. All of the internal organs with the exception of the speckled kidney are entirely unpigmented. The kidney, commencing 12 mm. behind the pectoral base, is traceable to within 35 mm. of the tip of the tail. The specimen is a female, with scarcely developed ovaries. Starting at the level of the anus, they are visible as slender strands of tissue until their termination 212 mm. behind the pectoral base.

Study Material.

1. A single specimen of *Avocettina* sp. taken by the Bermuda Oceanographic Expedition, in the cylinder of water off the Bermuda coast described in *Zoologica,* Vol. XVI, No. 1, p. 5:

No. 16,667; Net 762; 1000 F.; July 2, 1930; 498 mm.; Adult.

2. Specimens of *Avocettina bowersii* taken by the Templeton Crocker Expedition to the Gulf of California and Clarion Island (see *Zoologica,* Vol. XXII, No. 2, pp. 33-46; "The Templeton Crocker Expedition. II. Introduction, Itinerary, List of Stations, Nets and Dredges," by William Beebe):

a. No. 24,795; Sta. 134 T-2; 450 F.; March 30, 1936; 431 mm.; Adult; from 12 m. SW. of Cape Falso, Lower California.

b. No. 25,783; Sta. 165 T-2; 400 F.; May 17, 1936; 410 mm.; Adult; from 145 m. N. of Clarion Island, Revilla Gigedos.

Genus **Labichthys** Gill and Ryder, 1883.

Generic Characters: Nemichthyids with a single row of pores in the lateral line and the anus close behind level of pectoral base; caudal filament absent; teeth alternating in straight rows; dorsal origin slightly in advance of level of pectoral base; dorsal rays in middle third of body not short or spinous.

Parietals separated by suture; supraoccipital present; pterygoid vestigial, slender; mandible slightly shorter than ethmo-vomer; all opercular bones except preopercle present, but only feebly ossified; hyoid and branchial apparatus scarcely ossified; a single hypohyal; ceratohyal short, distinct from epihyal from which arise the eight strongly curved branchiostegals; basibranchials apparently absent; one coracoid; four radials; vertebrae about 175 to 180.

Labichthys, with a supraoccipital present, pterygoid vestigial but apparent and an opercular apparatus relatively well developed is, in these important characters at any rate, the least specialized of all the Nemichthyidae (with the possible exception of *Cercomitus*, which has not yet been studied osteologically).

Discussion: Only a single species, *L. carinatus* Gill and Ryder, 1883, has been described which belongs in this genus. *L. elongatus* Gill and Ryder, 1883, *L. gilli* Bean, 1890, and *L. bowersii* Garman, 1899, have, since their description, all been properly referred to *Avocettina*.

The three specimens of *L. carinatus* which have been previously taken are, respectively, the type and the two examples recorded by Parr (1932 and 1934). The present specimens agree well with the recorded measurements.

Labichthys carinatus Gill & Ryder, 1883.

Specimens Taken by the Bermuda Oceanographic Expeditions.

3 specimens; April to August, 1929 to 1931; 500 to 1,000 fathoms; from a cylinder of water 8 miles in diameter (5 to 13 miles south of Nonsuch Island, Bermuda), the center of which is at 32° 12′ N. Lat., 64° 36′ W. Long.; standard lengths 200+ to 470 mm.

Specimens Previously Recorded.

3 specimens; about 450 to 906 fathoms; western North Atlantic; recorded lengths 447 mm. and 605 mm.

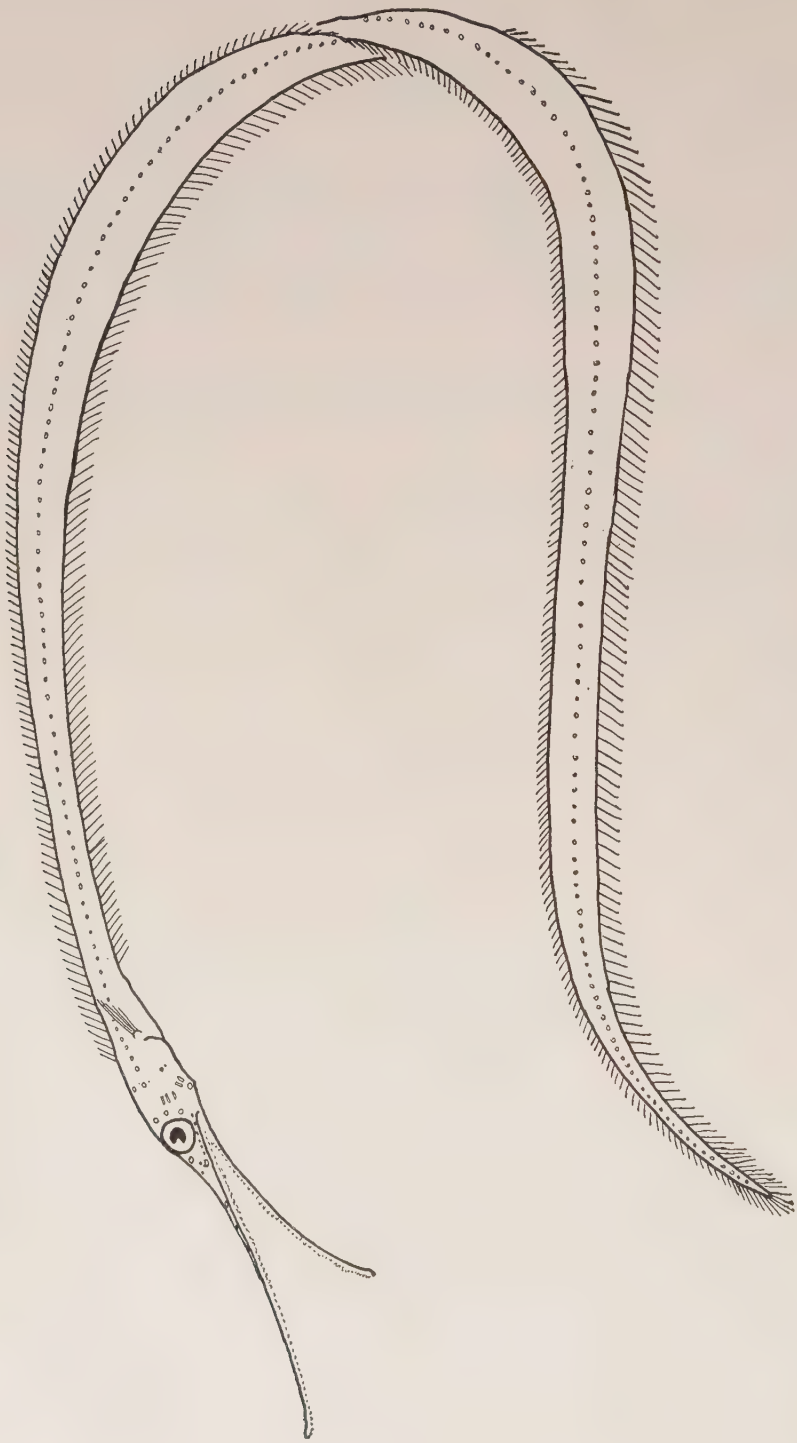
Description of Adult.

(Text-figs. 17, 18).

(From the two largest Bermuda specimens, 352 and 470 mm. in length; the smallest, 200+ mm. specimen was too badly damaged for exact measurements and counts to be made).

Color of Recently Preserved Specimens: Plain dark brown.

Proportions: Maximum depth (near middle of body) in length 36 to 41.5 (2.4 % to 2.8 %); head in length 7 to 7.6 (13.2 % to 14 %); eye in head 12.4 to 12.8, in postorbital 2.3 to 2.6, (1.06 % to 1.1 % of length); snout in head 1.36 to 1.39 (9.7 % to 10.3 % of length); postorbital in head 4.1 to 5, in snout 3.6 to 4, (2.5 % to 2.8 % of length); interorbital in head 15.6 to 16.5, in eye 1.2 to 1.3, (0.8 % to 0.9 % of length); maxillary extending slightly beyond posterior margin of orbit; tip of snout to tip



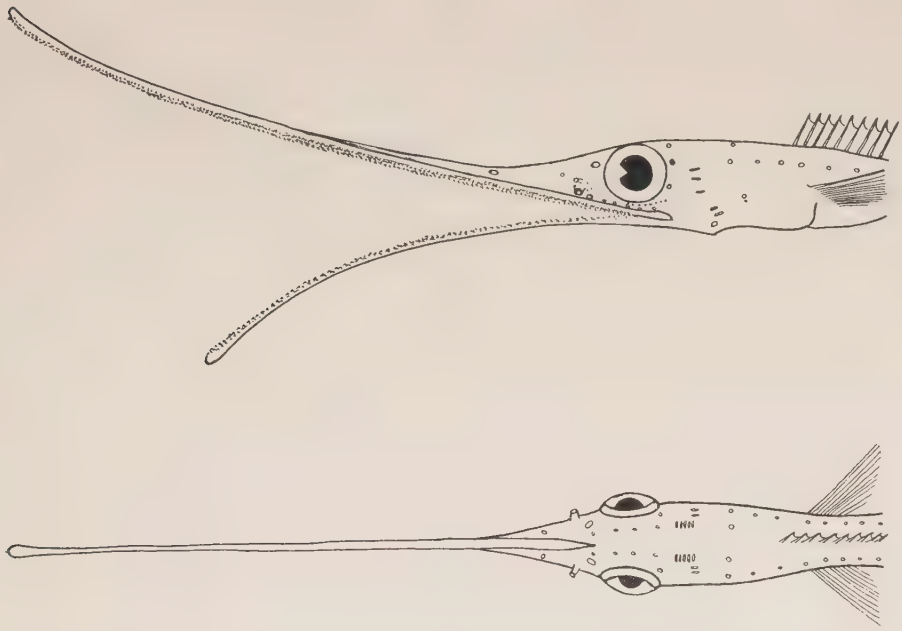
Text-figure 17.
Labichthys carinatus. Standard length 470 mm. The complete numbers of fin rays are not indicated.

of mandible in length of snout 3.1 to 3.2 (3 % to 3.3 % of length); pectoral base to anal origin in postorbital length 1.3 to 1.4 (2 % of length).

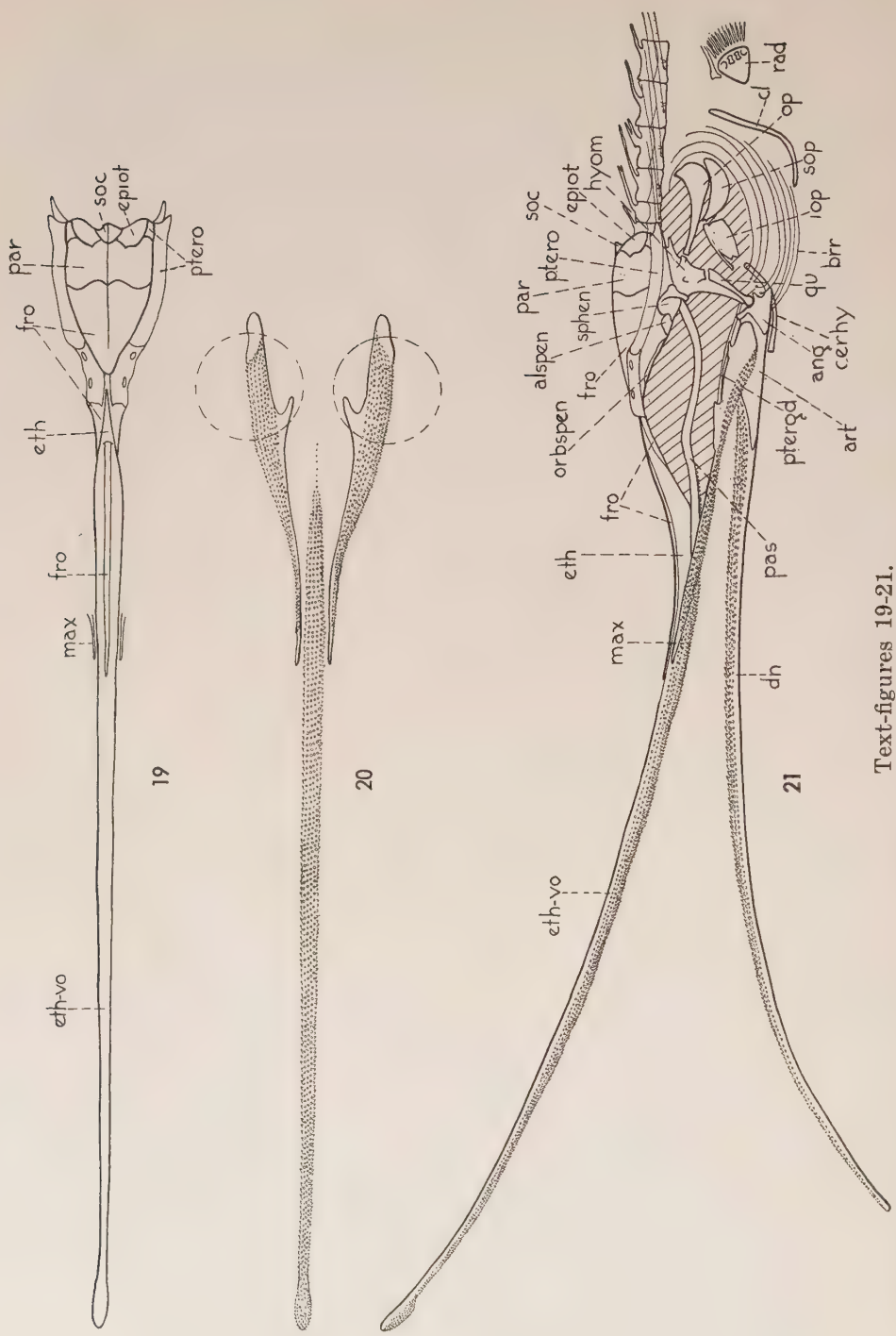
Teeth: (Text-figs. 3A, 19, 20, 21). The dentition of *Labichthys* agrees closely with that of *Avocettina* (see page 369) except in the following details: there are only 9, not 13, rows of teeth both on the mandible and on the ethmo-vomer; the teeth of the latter bones are more slender than those either on the mandible or than those of *Avocettina;* finally, there is a total of only about 220 teeth in a straight line along the mid-line of the ethmo-vomer, instead of about 260, as in both *Avocettina* sp. and *A. bowersii.* Both jaws are furnished with terminal knobs, but the latter are smaller and more elongate, less spherical than in *Avocettina.*

Fins: Pectoral rays 13, originating under second to fourth dorsal ray and beneath third to seventh lateral line pore, the dorsal origin, therefore, being slightly in front of pectoral base. (In the type specimen, which was reexamined by us at the United States National Museum, the pectoral commences under the sixth pore). First pectoral ray expanded and thickened, second and third similar, but smaller. Dorsal and anal rays so damaged that their numbers cannot be counted or their relative lengths determined, except that the anal rays are, as usual in this group, considerably longer than the dorsal rays. The anal originates under the eleventh to thirteenth dorsal ray and the seventh to twelfth lateral line pore. (In the type the anal commences under the space between the ninth and tenth pores; in the type description a count of 268 dorsal and 287 anal rays is given).

Pores and Vertebrae: There are 176 and 179 pores in the lateral line, the first three to six occurring in front of the pectoral base. An equal number of vertebrae was found in the specimen which was cleared and stained. (In the type there are 180 pores).

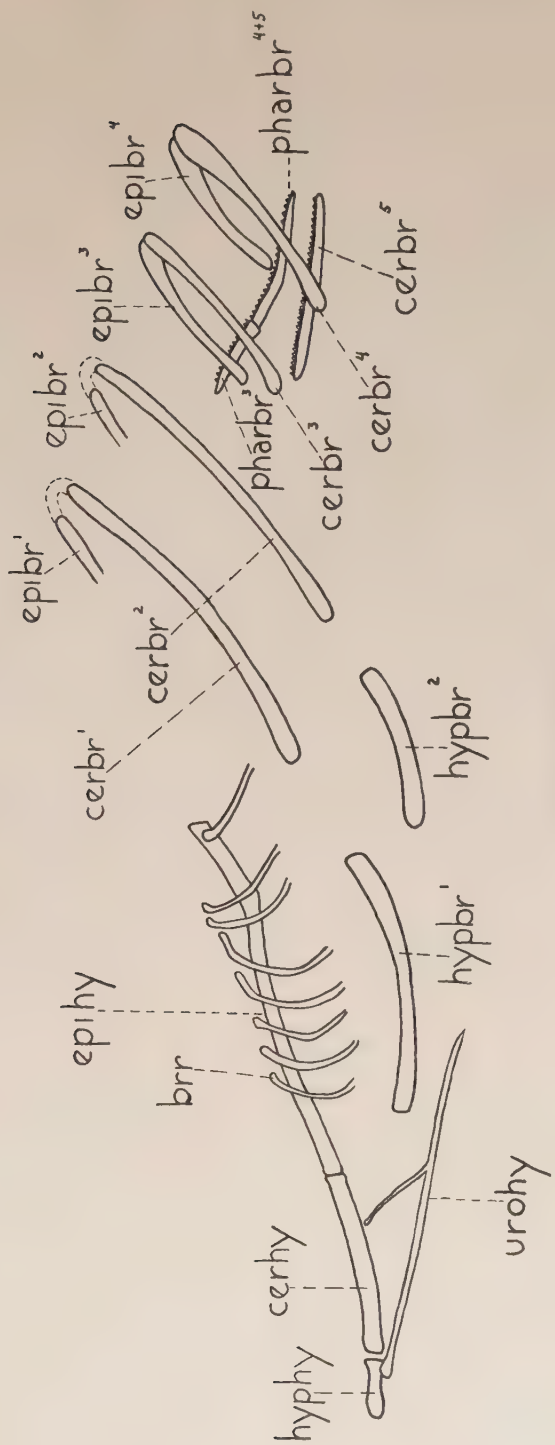


Text-figure 18.
Labichthys carinatus. Head, lateral (upper) and dorsal (lower) views. Standard length 470 mm. (x 1.8).



Text-figures 19-21.

Labichthys carinatus. **19.** Skull of adult, dorsal view; standard length 470 mm. (x 3.1). **20.** Same, teeth of upper jaw and vomer, ventral view. (x 3.1). **21.** Same, bones of head, pectoral girdle and anterior part of vertebral column, lateral view. (x 3.1).



Text-figure 22.

Labichthys carinatus. Hyoid and branchial apparatus of adult, standard length 470 mm. (x 16.4).

Osteology: (Text-figs. 19-22). With the characteristics of the genus. Unfortunately the entire trunk, including the vertebral column, fins and tail, fell to pieces during the staining process, so that no details can be given of this region except that the vertebral column appeared to be fairly well ossified and the dorsal and anal finrays strongly so. The jaws and pectoral fin were likewise strongly stained, but the rest of the skull as well as the hyoid and branchial apparatus showed exceedingly little ossification.

Discussion: The present specimens agree well with the type specimen. With the percentages given by Parr (1932, p. 16) for a 605 mm. specimen, our smaller examples differ in having relatively slightly shorter snouts (9.7 % to 10.3 %, not 11.9 %, of length) and smaller eyes (1.06 % to 1.1 %, not 1.16 %, of length). The postorbital length of the head is identical, relative to the length, in all three specimens, although the distance from pectoral base to anal origin is again slightly smaller in the present specimens (2 % instead of 2.8 % of length). Another slight difference is that in our specimens the eye and the dorsal rim of the orbit do not protrude so far above the line of the snout and skull, as depicted in Parr's Fig. 9 (1932, p. 18). Finally, the interorbital width in our specimens is greater than in Parr's (0.8 % to 0.9 %, instead of 0.73 %, of length).

The rostral ridges which, by their prominence in the shrunken type, gave the species its name, are not, as Parr has pointed out, very noticeable in fresh specimens. From the present drawing of the skull (Fig. 19) it will be seen that the ridges are merely the postero-lateral edges of the ethomo-vomer which fold up over the anterior end of the frontal. The same general effect is found in both *Avocettina* and *Nemichthys*.

Study Material.

The following list gives the catalogue number, depth in fathoms, date of capture, length and growth stage of each specimen of *Labichthys carinatus* taken by the Bermuda Oceanographic Expeditions. All were caught in the cylinder of water off the Bermuda coast described in *Zoologica*, Vol. XVI, No. 1, p. 5.

No. 9,704; Net 36; 900 fathoms; April 24, 1929; 352 mm.; Adult.
No. 16,459; Net 756; 1,000 fathoms; July 1, 1930; 470 mm.; Adult.
No. 22,309; Net 1143; 500 fathoms; Aug. 7, 1931; 200+ mm.; Adult.

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28.

Caudal Skeleton of Bermuda Shallow Water Fishes. III. Order Iniomi: Synodontidae.[1]

GLORIA HOLLISTER
Department of Tropical Research.

(Text-figures 1-18).

OUTLINE.

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Synodus intermedius 396

INTRODUCTION.

This is the third of a series of papers dealing with the caudal skeleton of Bermuda fishes[2]. The shallow-water Iniomi of Bermuda are represented by one family, two genera and three species.

In identifying specimens of the genus *Synodus*, before preparing them for osteological study, all the material runs to *S. intermedius* and *S. foetens*. All characters agree with Norman's "A Revision of the Lizard-Fishes of the Genera *Synodus*, *Trachinocephalus*, and *Saurida*." P.Z.S. of London, 1935.

For Caudal Fin Terminology, complete Bibliography, and method of preparing specimens for this study refer to Part I.

The length of specimens in this paper is standard length unless otherwise stated.

I am indebted to the United States National Museum for two specimens of *Trachinocephalus myops*.

This opportunity is taken to thank Dr. William Beebe, Director of this department, and Mr. John Tee-Van, General Associate, for their cooperation.

The drawings are by Mr. George Swanson and the author.

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[1] Contribution No. 548, Department of Tropical Research, New York Zoological Society. Contribution from the Bermuda Biological Station for Research Inc.

[2] Caudal Skeleton of Bermuda Shallow Water Fishes. I. Order Isospondyli: Elopidae, Megalopidae, Albulidae, Clupeidae, Dussumieriidae, Engraulidae. *Zoologica*, New York Zoological Society, Vol. XXI, Dec. 31, 1936.

Caudal Skeleton of Bermuda Shallow Water Fishes. II. Order Percomorphi, Suborder Percesoces: Atherinidae, Mugilidae, Sphyraenidae. *Zoologica*, New York Zoological Society, Vol. XXII, Oct. 7, 1937.

Key to Caudal Fin of Bermuda Shallow Water Iniomid Fishes.

INIOMI — Synodontidae

Group I — *Trachinocephalus myops*

1 simple vertebra, anterior to true caudal, without ribs, epipleural spines and haemal process.

Abdominal ribs present beyond the anterior margin of anal fin, extending to about mid-length and above 7th anal ray.

55 total vertebrae.

46 trunk vertebrae.

Group II

4 to 7 simple vertebrae, anterior to true caudal, without ribs, epipleural spines and haemal processes.

Abdominal ribs absent beyond the anterior margin of anal fin.

58 or 49 total vertebrae.

Sub-Group A — *Synodus foetens*

4 simple vertebrae anterior to true caudal.

Posterior interhaemal anal spine higher than long.

58 total vertebrae.

38 trunk or abdominal vertebrae with ribs.

Sub-Group B — *Synodus intermedius*

6 or 7 simple vertebrae anterior to true caudal.

Posterior interhaemal anal spine longer than high.

49 total vertebrae.

30 trunk or abdominal vertebrae with ribs.

This paper deals principally with the adult fishes, as does Part I on Bermuda Isospondyli and Part II on Bermuda Percomorphi, suborder Percesoces.

The Synodontidae are unlike the families studied in Parts I and II in having between the trunk and the typical caudal region vertebrae which lack ribs, characteristic of the trunk, and which also lack closed haemal arches bearing haemal spines, characteristic of the caudal. This area is immediately posterior to the abdominal or trunk region and dorsal to the anal fin whose interhaemals project upward almost to the vertebrae. Definite bottom living habits of this elongate fish may be responsible for the ventral modification of the vertebrae in this region above the anal fin.

In *Synodus* the posterior pair of ribs is dorsal to the anterior margin of the anal fin. In *Trachinocephalus* the posterior pair of ribs is dorsal to the anal fin at its mid-length. In a broad sense the caudal region of the synodonts includes all the vertebrae posterior to the last abdominal or trunk vertebra bearing ribs. In this paper the general caudal is divided into the anterior or precaudal and the posterior or true caudal. The precaudal includes all of the modified vertebrae posterior to the last trunk vertebra and anterior to the true caudal. The true caudal is the typical caudal, the vertebrae of which have closed haemals bearing spines.

The differences in the total vertebral counts of the three species is found in the trunk region and there is only slight variance in the counts of the precaudal and the caudal.

In the trunk region the ventral projections or stumps from the bases of the centra are called parapophyses, according to Starks' "Synonomy of the Fish Skeleton." In the precaudal and the true caudal regions the ventral projections are called zygapophyses according to the definition of caudal bones in Part I.

The true caudal of *S. foetens* and *S. intermedius* are so essentially similar that no illustrations have been included of the latter. The differences are described in the text.

The symbols used are: AD, adipose; AN, anal fin; BA, basiost; C, centrum; EP, epural; ES, epipleural spine; HA, haemal arch; HP, haemal process; HS, haemal spine; IS, interhaemal spine; NA, neural arch; NP, neural process; NS, neural spine; P, parapophysis; R, rib; SNP, specialized neural process; UN, uroneural; UR, urostyle; Z, zygapophysis; 1, 2, 3, etc., hypurals.

1. ***Trachinocephalus myops*** (Forster).

(Text-figs. 1-4).

Diagnostic Characters:

1 simple vertebra anterior to the true caudal without ribs, epipleural spines and haemal process.

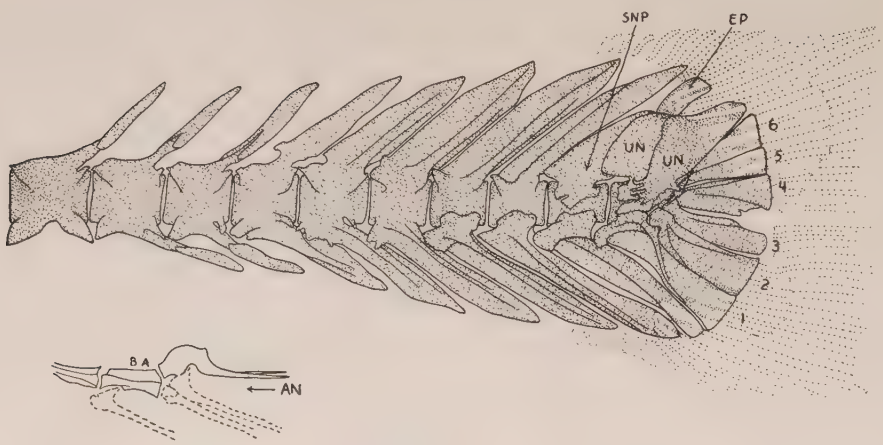
Posterior pair of ribs at about mid-length of anal fin, dorsal to the 7th anal ray.

Epipleural spines present above the entire length of the anal fin.

Vertebral count: 46 trunk. Total 55.

Material Studied.

Length.	*KOH Cat. No.*	*Cat. No.*	*Text-fig. No.*
275 mm.	2201	83784 U. S. Nat. Mus.	1
90 mm.	2200	71053 U. S. Nat. Mus.	
39 mm.	2174		2, 3
29 mm.	2139		4

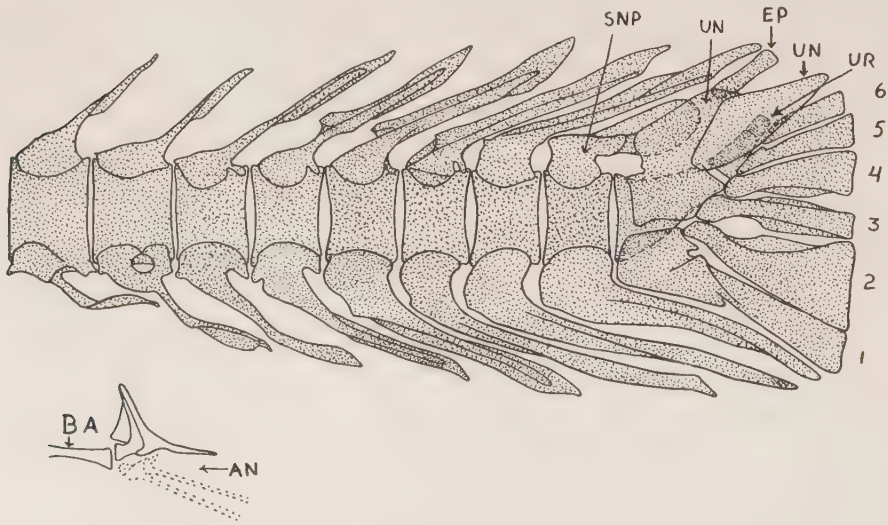


Text-figure 1.

Trachinocephalus myops. Tail of 275 mm. specimen showing the entire true caudal series following the last precaudal vertebra. (x 2.6).

Caudal Osteology.

Urostyle: In the 275 mm. specimen all except the anterior margin of the urostyle is covered by the uroneurals (Text-fig. 1). The visible part of the urostyle is identical in size and shape with the penultimate centrum. The notochord extends beyond the distal margin of the hypurals between the bifid base of the ninth ray, counting up from the median line. In the 39 mm. and 29 mm. specimens, where the ossification of the uroneurals overlapping the urostyle is not as dense as in the 275 mm. specimen, separate elements of the urostyle can be seen. These are less ossified in the



Text-figure 2.

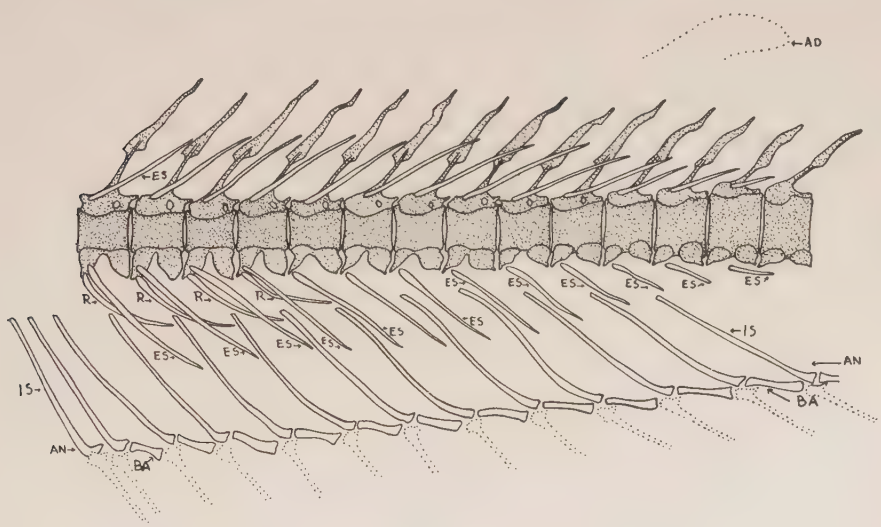
Trachinocephalus myops. Tail of 39 mm. specimen showing the entire true caudal series and the specialized neural process of the penultimate vertebra projecting between the adjacent uroneurals. (x 21.1).

29 mm. fish and there is a longer unossified area between the two segments. All the elements of the urostyle in the 39 mm. specimen are more consolidated and more heavily ossified than in the 29 mm. fish (Text-figs. 2, 3, and 4).

Uroneurals: There are two pairs of uroneurals, in all the specimens examined, which overlap and cover the urostyle and almost fill the area above and between the last neural spine and the sixth hypural (Text-figs. 1, 2, and 4). By dissecting, a third pair was found fused to the distal and inner surfaces of the posterior uroneurals. Dorsally, the shape of the two large pairs of uroneurals, separately and together, differs from *Synodus foetens*. In *Trachinocephalus* the bones of both pairs of uroneurals are larger (Text-fig. 1). In *Synodus foetens* the epural, and not the uroneurals, fills most of the area above the anterior uroneurals whereas the reverse is true in *Trachinocephalus*. In this fish the posterior pair of uroneurals elongate anteriorly, covering most of the lateral parts of the anterior pair and the bases of the hypurals. In *Synodus foetens* a third pair of uroneurals is present on the lateral part of the urostyle and the posterior pair, comparable with that of *Trachinocephalus*, is entirely dorsal to the urostyle (Text-fig. 5).

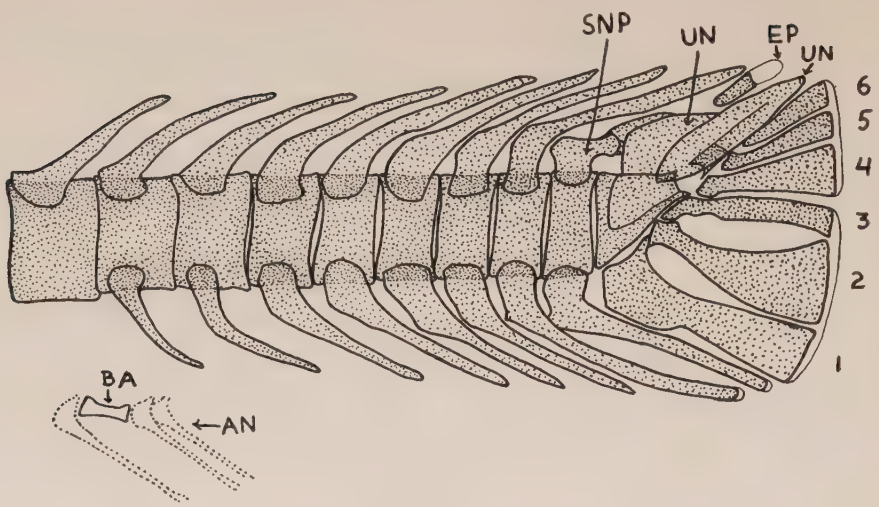
Hypurals: There are six hypurals, three below and three above the median line. There is no space between the dorsal and ventral surfaces of these bones but they remain unfused even in the largest specimen. In the smallest specimen examined a continuous band of cartilage covers the distal ends of the hypurals (Text-fig. 4).

Epurals: There is one epural in all specimens. In the 29 mm. fish the distal half is unossified (Text-fig. 4). The epural in the 275 mm. specimen is rectangular-shaped and twice as long as wide (Text-fig. 1). In *Synodus foetens* of 300 mm. the epural is a much longer bone with a slender dorsal tip which resembles the adjacent neural spine. Ventrally, it becomes broader



Text-figure 3.

Trachinocephalus myops. Precaudal series of tail of 39 mm. specimen following the last four trunk vertebrae. At the right is the one simple vertebra preceding the true caudal series. Below is the anal fin with interhaemal spines projecting dorsally and overlapping the epipleural spines. (x 13.3).



Text-figure 4.

Trachinocephalus myops. Tail of 29 mm. specimen showing the entire true caudal following the one simple vertebra of the precaudal series. Ossification is not complete, which is shown by the partly ossified epural and unossified interhaemals. A band of cartilage outlines the distal margin of the hypurals. (x 21.1).

and fills the area above the uroneurals, which are not as large as those of *Trachinocephalus.*

Specialized Neural Processes: On dissecting the neural process of the centrum preceding the urostyle, a median dagger-like projection was found which extends posteriorly within the uroneurals uniting dorsally the penultimate and urostyle centra (Text-figs. 12, 13, and 14). This is also found in *Synodus.*

Caudal Fin Ray Count:

275 mm.	13 + 9 = 22
	13 + 10 = 23
39 mm.	13 + 10 = 23
29 mm.	13 + 9 = 22

Additional Characters Worthy of Note: There are ten vertebrae between the trunk and the true caudal series which are called precaudal in this paper. These vertebrae lack ribs, characteristic of the trunk, and also closed haemals bearing haemal spines, characteristic of the typical caudal. Ventrally, the haemal canal is open between the stump-like zygapophyses. Nine centra of this series bear epipleural spines whose lengths decrease posteriorly. At the caudal end of the series there is one simple vertebra which is anterior to the beginning of the true caudal series. This vertebra lacks ribs, epipleural spines, and haemal processes. The last pair of epipleural spines is dorsal to the posterior interhaemal spine of the anal fin. Following the ten precaudals is the true caudal series consisting of nine typical caudal vertebrae, counting the urostyle segment as one. The position of the anterior true caudal vertebra is dorsal to the basiost which articulates the posterior and penultimate anal rays. Besides the differences in the various counts one conspicuous general difference between *Trachinocephalus* and

Synodus is the much heavier development of the neural and haemal processes of the true caudal of *Trachinocephalus*.

The description, in general, was taken from the two smaller specimens because the place of capture of the larger fish was not Bermuda.

2. **Synodus foetens** (Linnaeus).

(Text-figs. 5-18).

Diagnostic Characters:

Posterior interhaemal anal spine higher than long.

4 simple vertebrae, anterior to the true caudal series, without ribs, epipleural spines and haemal processes.

Last posterior pair of ribs on the centrum which is anterior by two centra to the anterior external margin of the anal fin.

Epipleural spines present on centra to about the mid-length of the anal fin.

Vertebral count: 38 trunk. Total 58.

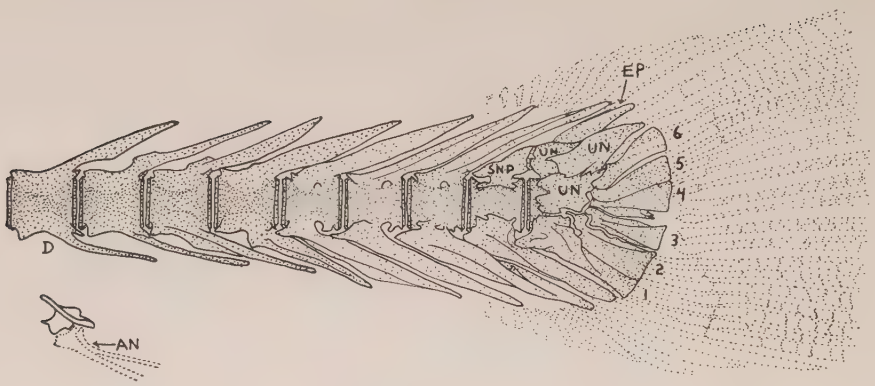
Material Studied.

Length.	*KOH Cat. No.*	*Text-fig. No.*
300 mm.	1081	5, 6, 8, 12-18
153 mm.	770	
130 mm.	997	7
75 mm.	2176	
45 mm.	2177	
33 mm.	2181	
32 mm.	2180	10
28 mm.	2182	11

Caudal Osteology.

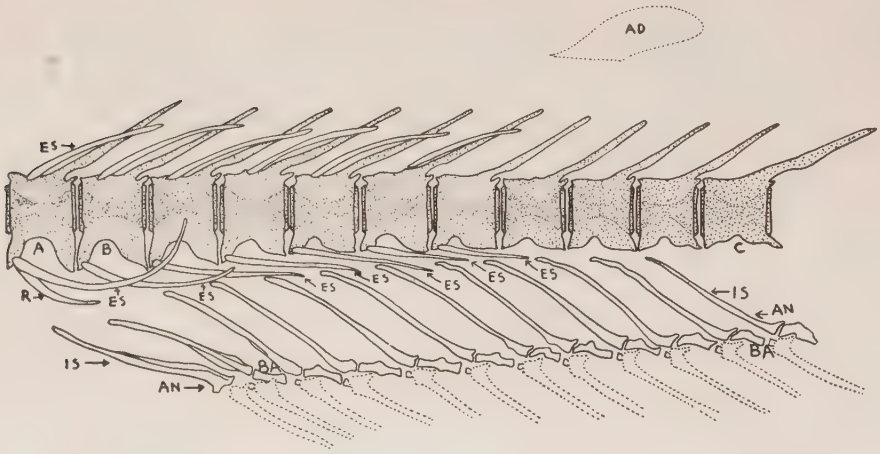
Urostyle: In the 300 mm. specimen all except the anterior margin of the urostyle segment is covered by the uroneurals and, ventrally, by the bases of the first and second hypurals. The anterior margin is identical in form with that of the preceding centrum. The clear notochord extends beyond the margin of the hypurals between the bifid base of the 10th ray, counting up from the median line. The notochord extends 5.25 mm. beyond the tips of the posterior dorsal pair of uroneurals (Text-figs. 5 & 12). In the 130 mm. specimen the posterior end of the urostyle is seen through the overlying uroneurals and located above the bases of the fourth and fifth hypurals. Beyond is a short unossified area which is followed by a small hour-glass-shaped bony segment dorsal to the bases of the fifth and sixth hypurals. The cartilaginous notochord extends between the uroneurals beyond the distal margin of the sixth hypural (Text-fig. 7). In the 75 mm. specimen the terminal bony segment, comparable with that of the 130 mm. specimen, is slightly longer and there is less unossified area between it and the preceding segment. It is more rod-like and lacks the hour-glass shape of the larger specimen (Text-fig. 8). Text-figures 10 and 11 show the development of the urostyle in specimens 32 mm. and 28 mm. in length.

Uroneurals: In the 300 mm. specimen three pairs of uroneurals overlap each other on the surface of the urostyle (Text-figs. 5 and 12). By dissecting, a diminutive fourth pair was found fused to the distal end and inner surface of the posterior-dorsal uroneurals (Text-figs. 7 and 8). In a 75 mm. specimen this small pair of uroneurals is unfused and separate from the overlapping uroneurals (Text-fig. 9). In the two smallest specimens, 32 mm. and 28 mm., only one pair of the large uroneurals is developed.



Text-figure 5.

Synodus foetens. Tail of 300 mm. specimen showing the entire true caudal and the relative position of the posterior interhaemal of the anal fin. See Text-figure 18 for front view of vertebra D. (x 2.1).



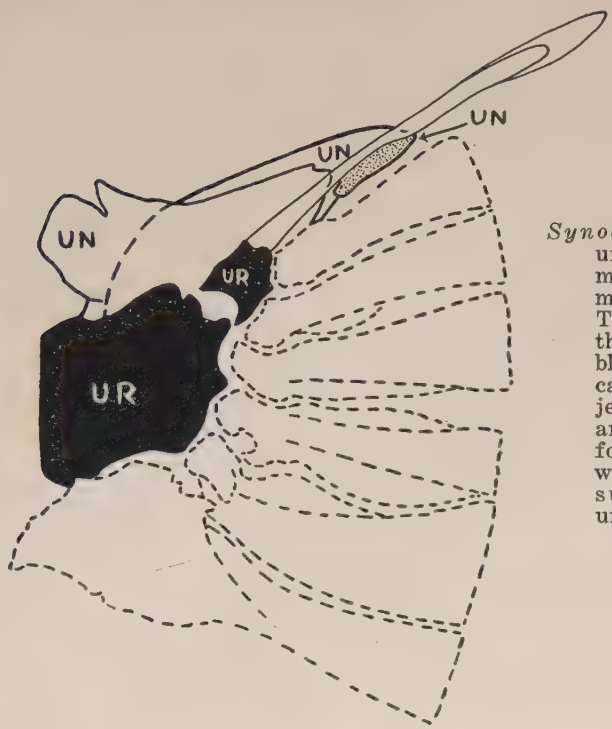
Text-figure 6.

Synodus foetens. Precaudal of tail of 300 mm. specimen following the last vertebra. At the right are the four simple vertebrae preceding the true caudal and below is the anal fin with interhaemals overlapping dorsally the ends of the epipleurals. See Text-figures 15, 16 and 17 for front views of vertebrae A, B and C. (x 2.1).

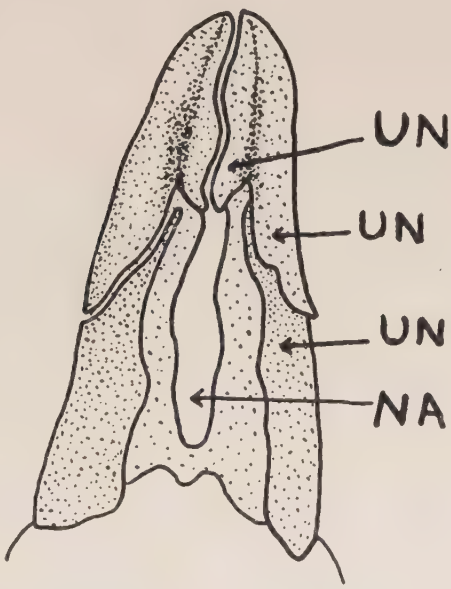
Hypurals: There are six hypurals, three below and three above the median line. Although the hypurals in the 300 mm. specimen have no space between the dorsal and ventral surfaces, these bones are not fused. In the smallest fish a band of cartilage outlines the distal margin of the hypurals (Text-fig. 10).

Epurals: There is one epural in specimens of all lengths. In the smallest the epural is unossified and in the 32 mm. specimen one quarter remains unossified (Text-figs. 10 and 11).

Specialized Neural Processes: In dissecting the neural process of the centrum preceding the urostyle a median dagger-like projection was found which extends posteriorly within the uroneurals uniting dorsally the penul-

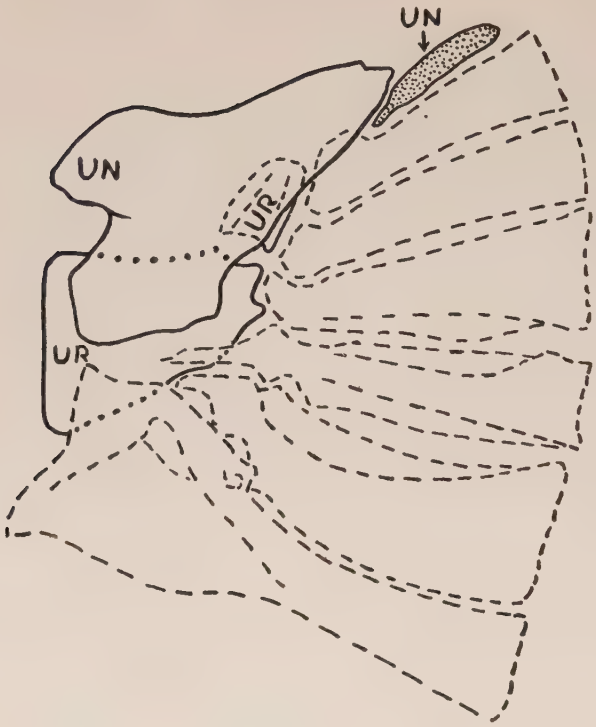


Text-figure 7.
Synodus foetens. Dissected urostyle of 130 mm. specimen with all uroneurals removed from upper side. Two ossified elements of the urostyle are shown in black and in outline, the cartilaginous notochord projecting beyond. The stippled area is one bone of the fourth pair of uroneurals which are fused to the inner surface of the dorsal uroneurals. (x 21.8).



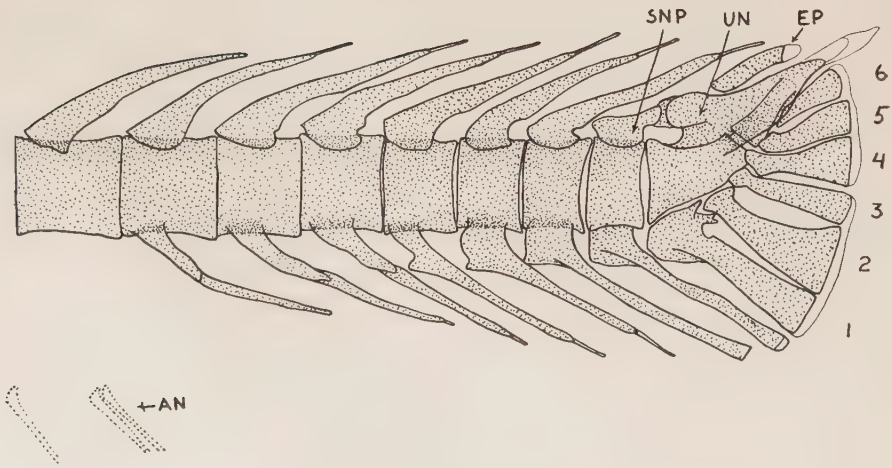
Text-figure 8.
Synodus foetens. The overlapping uroneurals above the urostyle in the 300 mm. specimen as seen from the posterior. The upper UN represents the small uroneurals stippled in Text-figure 7. (x 11.8).

timate and urostyle centra (Text-figs. 12, 13, 14). In the smallest specimen, 28 mm., which is only partially ossified, this neural process is not present (Text-fig. 11). But in the 32 mm. fish it is present and ossified (Text-fig. 10).



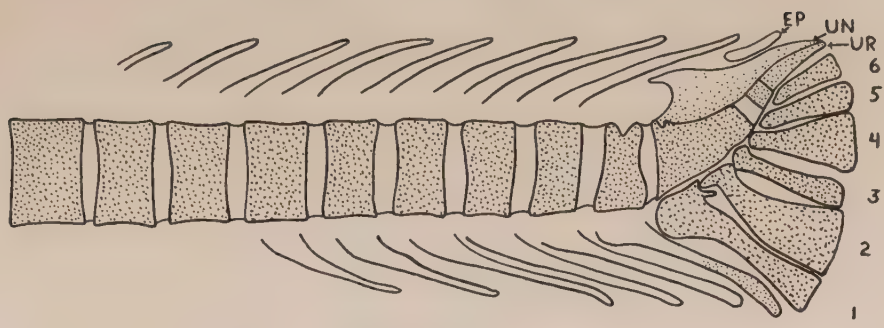
Text-figure 9.

Synodus foetens. Urostyle of 75 mm. specimen with the posterior dorsal uroneurals removed to show the small underlying pair which are unfused in this young specimen. (x 36).



Text-figure 10.

Synodus foetens. Tail of 32 mm. specimen showing entire true caudal following the posterior simple vertebra of the precaudal series. Part of the epural and none of the internal bones of the anal fin are ossified. A cartilaginous band outlines the distal margin of the hypurals. (x 26.8).



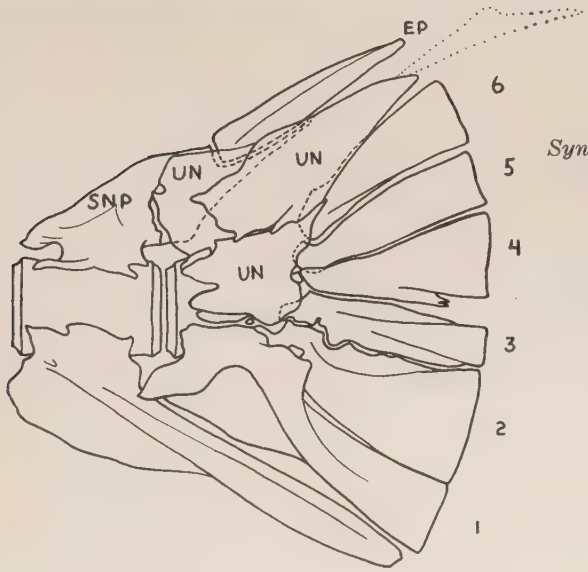
Text-figure 11.

Synodus foetens. Tail of 28 mm. specimen showing vertebral column unsegmented and only partly ossified. None of the neurals or haemals is ossified. (x 21).

Caudal Fin Ray Count:

300 mm.	12 + 10 = 22
45 mm.	11 + 9 = 20
75 mm.	13 + 10 = 23
	12 + 9 = 21
32 mm.	11 + 8 = 19
	9 + 10 = 19
28 mm.	12 + 8 = 20
	11 + 9 = 20

Additional Characters Worthy of Note: There are ten precaudal vertebrae between the trunk and the true caudal series. These vertebrae lack ribs and closed haemals with haemal spines (Text-fig. 6). Ventrally, the haemals are open between the stump-like zygapophyses (Text-figs. 16 and



Text-figure 12.

Synodus foetens. Urostyle with penultimate vertebra of 300 mm. specimen showing in dashed line the median projection of the specialized neural process between the uroneurals. Also in dashed line are the bases of the hypurals which are covered by the uroneurals in the completely ossified specimen. (x 5.1).

Text-figure 13.

Synodus foetens. Lateral view of specialized neural process of penultimate centrum of 300 mm. specimen dissected to show single posterior projection which extends between the bones of two pairs of uroneurals seen in Text-figure 12. (x 10.4).

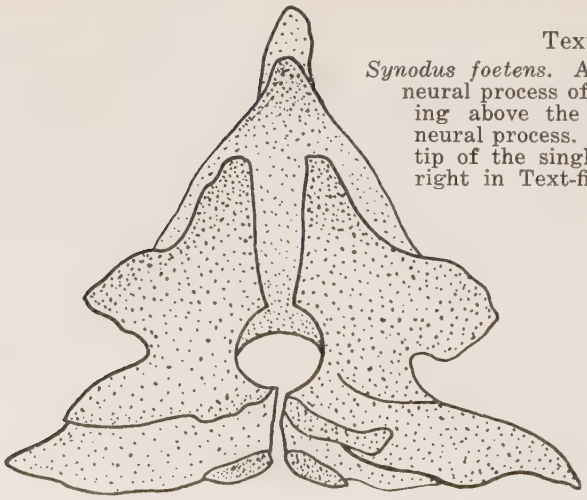
17). The six anterior centra of this series have epipleural spines whose lengths decrease posteriorly. Following the six are four simple vertebrae, anterior to the true caudal, without ribs, epipleural spines and haemal processes. The position of the last pair of epipleural spines is dorsal to the mid-length of the anal fin (Text-fig. 6). There are nine typical caudal vertebrae, counting the urostyle segment as one (Text-fig. 18). The anterior caudal vertebra is dorsal to the last interhaemal spine of the anal fin (Text-fig. 5). The interhaemals are long and stout and extend upward and in an anterior direction from the articulating basiosts almost to the centra.

3. **Synodus intermedius** (Agassiz).

Diagnostic Characters:

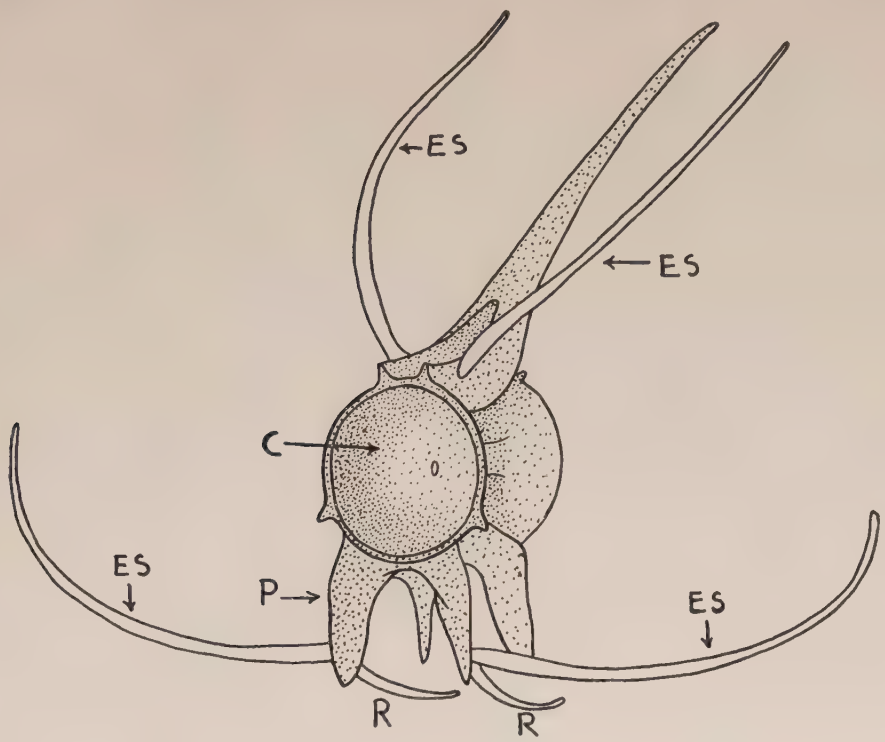
Posterior interhaemal anal spine longer than high.

6 or 7 simple vertebrae, anterior to the true caudal series, without ribs, epipleural spines, and haemal processes.



Text-figure 14.

Synodus foetens. Anterior view of specialized neural process of penultimate centrum showing above the neural canal the reduced neural process. The dorsal projection is the tip of the single median bone seen on the right in Text-figure 13. (x 23.2).



Text-figure 15.

Synodus foetens. Posterior trunk vertebra of 300 mm. specimen with ribs, epipleural spines and open haemal. This vertebra is lettered A in Text-figure 6. (x 30.3).

Last posterior pair of ribs on the centrum which is anterior by three centra to the external anterior margin of the anal fin.

Last posterior pair of epipleural spines on the centrum dorsal to the external anterior margin of the anal fin.

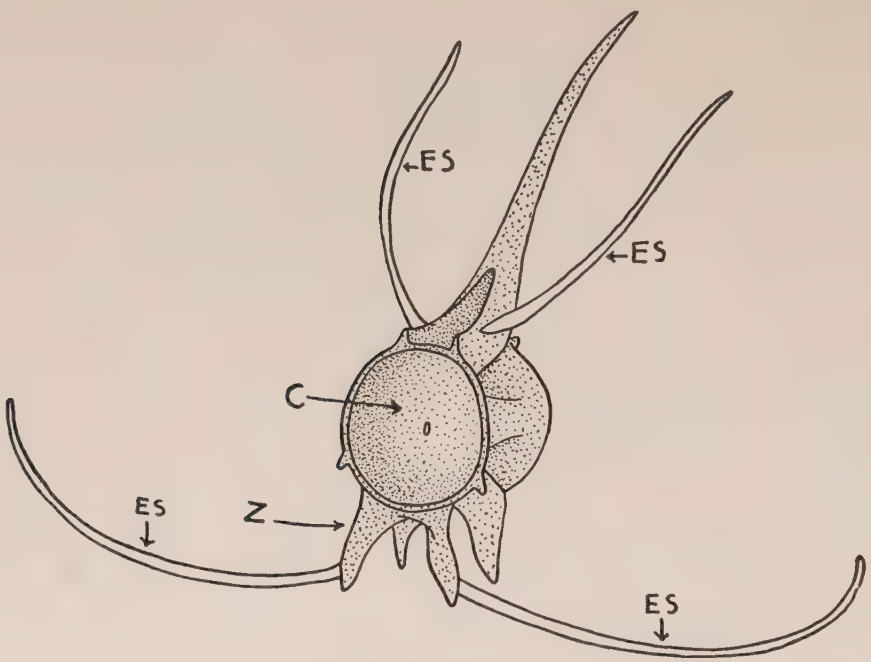
Vertebral count: 30 trunk. Total 49.

Material Studied.

Length.	*KOH Cat. No.*
270 mm.	493
202 mm.	638
135 mm.	677
50 mm.	2175

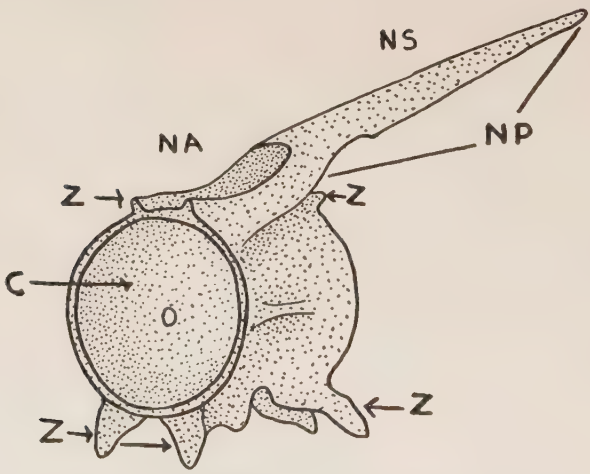
Caudal Osteology.

The general caudal pattern of *Synodus intermedius* is similar to that of *Synodus foetens* but differences of detailed structure make it easy to distinguish between the two species. *S. intermedius* is shorter and more compact than *S. foetens* as is primarily shown by a comparison of the vertebral counts. *S. intermedius* is shorter by eight to ten vertebrae, which difference is found in the trunk region. The precaudal and caudal counts of the two species are almost the same. In *S. intermedius* the anal fin is notice-



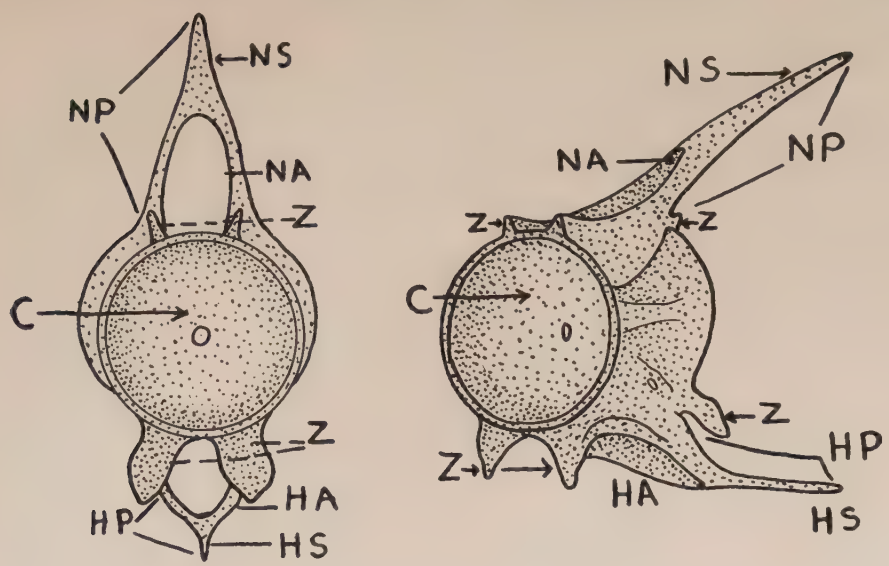
Text-figure 16.

Synodus foetens. First precaudal vertebra of 300 mm. specimen which follows the vertebra shown in Text-figure 15. It is lettered B in Text-figure 6. (x 30.3).



Text-figure 17.

Synodus foetens. The posterior simple vertebra of the precaudal series of a 300 mm. specimen which lacks ribs, epipleural spines and has an open haemal. This vertebra is penultimate to the true caudal series and is lettered C in Text-figure 6. (x 8.2).



Text-figure 18.

Synodus foetens. The anterior and first vertebra of the true caudal series of a 300 mm. specimen showing closed haemal process with haemal spine. This vertebra is lettered D in Text-figure 6. (x 6.1).

ably shorter with fewer rays and interhaemals. In the precaudal region of *S. foetens* there is a greater number of simple vertebrae which are dorsal to the entire anal fin. Epipleural spines are present on only three or four anterior centra of the precaudal series leaving six or seven simple vertebrae. On the urostyle the ventral pair of uroneurals is much smaller than that of *S. foetens*. The base of the first hypural extends dorsally covering almost the lower half of the urostyle and, from above, the base of the anterior-dorsal uroneurals extends down over the urostyle. Between these two bones and entirely lateral in position is an insignficant pair of uroneurals. The anterior hypurals are more sharply pointed and the neural processes in the precaudal area are considerably heavier than those of *S. foetens*.

Caudal Fin Ray Count:

270 mm.	12 + 9 = 21
135 mm.	11 + 10 = 21
202 mm.	12 + 9 = 21
	12 + 10 = 22
50 mm.	12 + 10 = 22
	11 + 9 = 20

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Names in ***bold face*** *indicate new species; numbers in* ***bold face*** *indicate illustrations.*

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